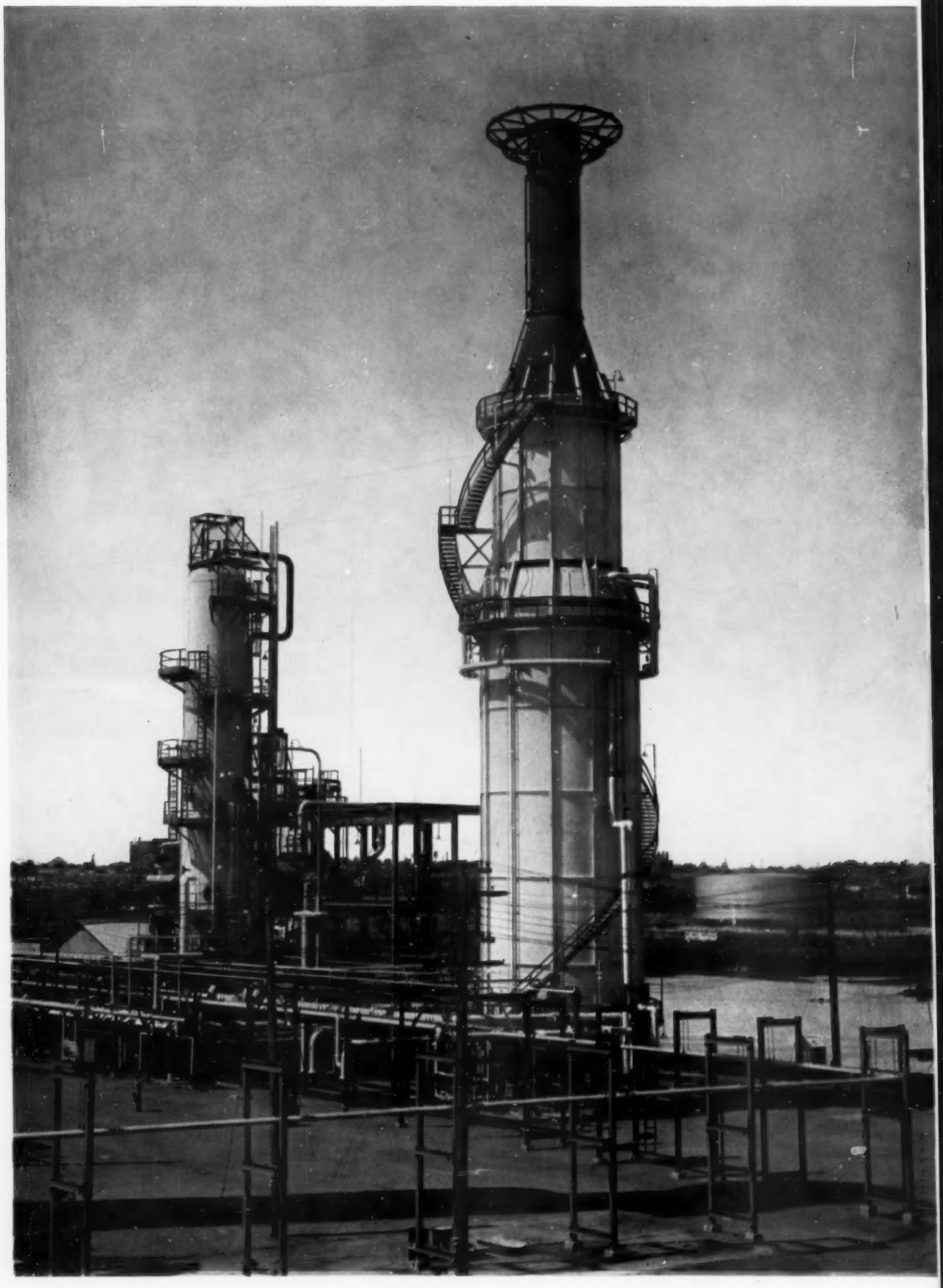
WORLD PETROLEUM



TWENTY-SEVENTH
ANNUAL
REFINERY REVIEW

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Lummus to Build 200,000,000 lb. per Year Ethylene Plant for Petroleum Chemicals, Inc.

Installation Designed for 50% Expansion

The Lummus Company is presently designing and will build for Petroleum Chemicals, Inc. at Lake Charles, Louisiana a plant to produce 200,000,000 pounds per year of ethylene. Scheduled for completion by the end of 1957, the plant is designed to permit expansion of output to 300,000,000 pounds.

The plant will use Lummus' ethylene process and will draw refinery gases supplemented with LPG from the nearby refineries of Cities Service and Continental Oil, by whom P.C.I. is jointly owned. Ethylene will be made in two grades — the top grade 99.8% pure — the second 98.5%. By-products will be 95% pure propylene, C_4s, and an aromatic distillate.

Cracking section of the plant features an improved Lummus heater which embodies years of research and development by Lummus' Heater Division. Equipment in the Lummus-designed low-temperature fractionation unit includes 12,500-hp gas turbines which drive the centrifugal charge and refrigeration compressors; exhaust from these turbines generates high-pressure steam in three waste heat boilers. The system utilizes high efficiency expanders to recover very low temperature refrigeration.

This plant brings the total of Lummus designed ethylene plants to 14, with a combined capacity of over 3 million pounds per day.

Part of the new plant's ethylene output will be sold to Calcasieu Chemical Corporation, which will use it to produce ethylene oxide and glycol in a plant adjacent to the ethylene unit. Lummus is currently designing and will build the Calcasieu installation.

Lummus has over half a century of experience with chemical and petrochemical projects. Why not discuss your next project with a Lummus representative.

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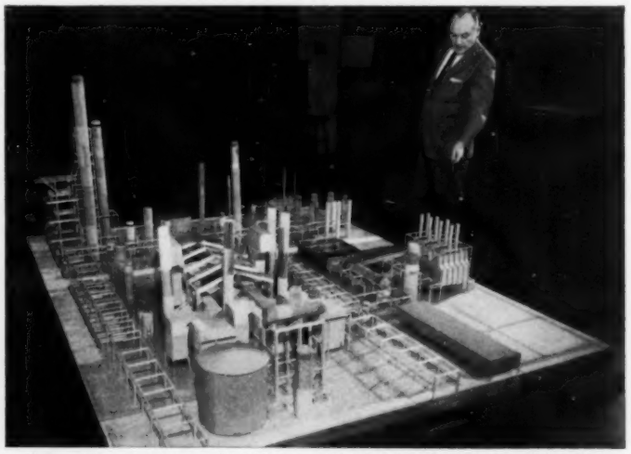

Lummus engineer points out cracking heaters in model of Petroleum Chemicals, Inc. ethylene plant.

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World Petroleum

THE MANAGEMENT PUBLICATION OF THE INTERNATIONAL PETROLEUM INDUSTRY

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THIS MONTH'S COVER

The illustration on the cover is of a 22,500 b/d viscosity breaker, located at the Gulf Oil Corp.'s Philadelphia refinery. This plant operates on the heavy residue of an asphaltic crude received from a vacuum unit. This charge enters the cracking coils of the heater at 600 F, and the temperature is gradually raised to above 900 F. Several tons of sulfur are extracted from effluent gas. Liquid products include gasoline and viscosity-broken tar which requires only slight blending with lower-viscosity fuel oil to be salable as No. 6 fuel oil. The heater was designed and built by Petro-Chem Development Co. The vis-breaking unit was the first new unit in Gulf's Philadelphia refinery to receive the color treatment in the refinery's painting project "Operation Rainbow." Color photographs are reproduced through the courtesy of Donald C. White, editor of *The Orange Disc*, Gulf house magazine.

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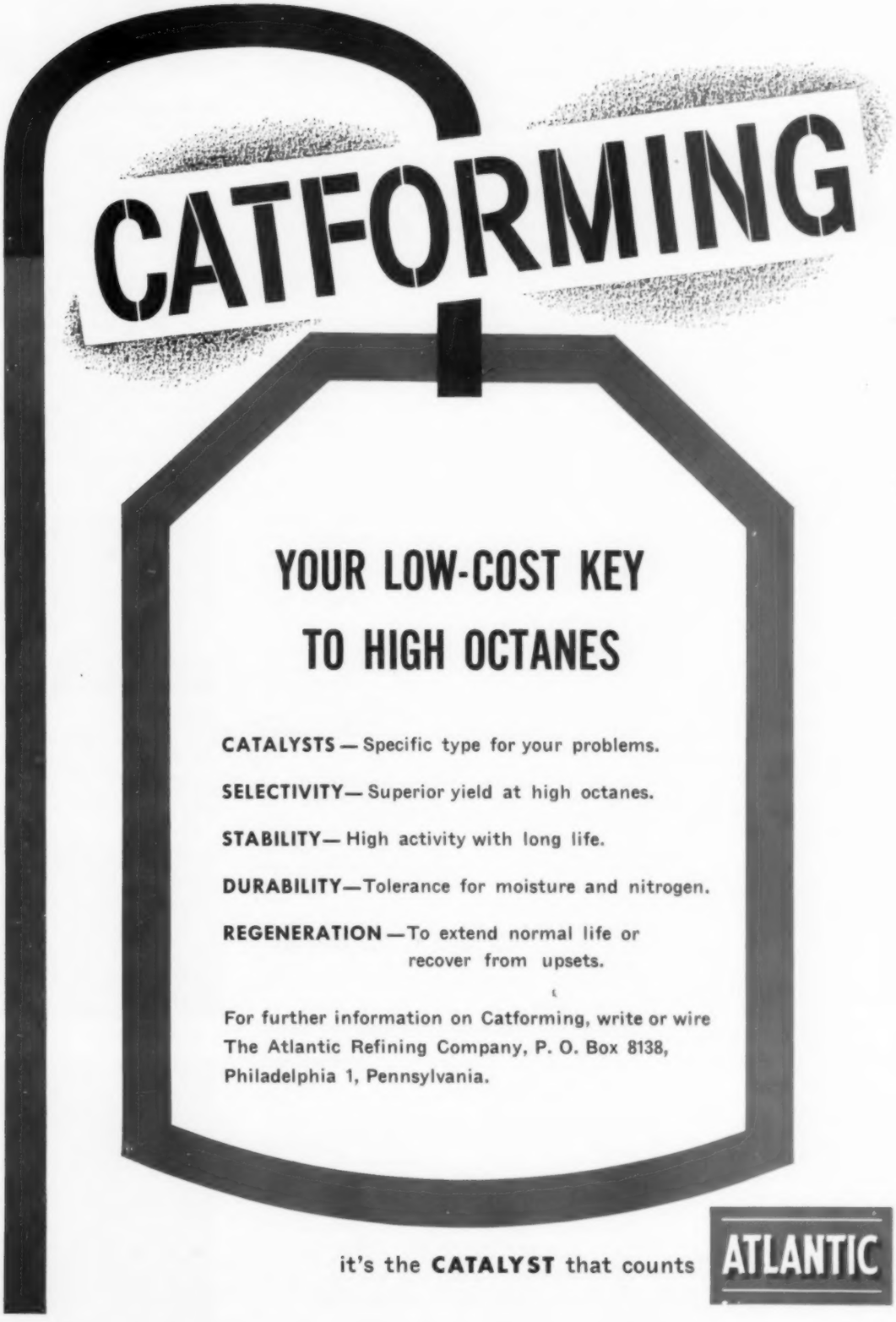
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Oil Company Staff Changes

OLIVER E. AUER, formerly senior sales engineer of Girdler Co.'s gas-processing division, has joined sales staff of Procon Incorporated—refinery, petrochemical, and chemical-plant construction company—with headquarters at Des Plaines, Ill.

ARTHUR B. KENT has been appointed chief chemist at Sun Oil Co.'s Marcus Hook, Pa., refinery—succeeding George E. Reese, retired.

T. L. McWILLIAMS, at Memphis, Tenn., has been appointed assistant superintendent of Texas Gas Transmission Corp.'s compressor-station department.

TALMAGE LOVELADY, of Worland, Wyo., has been elected president of Liquefied Petroleum Gas Assn.

RICHARD C. McCURDY, president of Shell Chemical Co., has been appointed chairman of the Mineral Sciences Fund at Stanford University. With Shell since 1933, he spent several years as manager of Shell Caribbean Petroleum Co., in Venezuela. In his new post, Mr. McCurdy's primary responsibility will be to attract gift support to the university's School of Mineral Sciences.

R. E. CORNWELL has been appointed president of Union Carbide Development Co., division of Union Carbide Corp. Starting with Union Carbide in 1923, he has held key positions with both Linde Co. and Union Carbide Chemicals Co., both divisions of the corporation.

R. G. FOLLIS, board chairman of Standard Oil Co. of California, has been elected board chairman of the National Industrial Conference Board. Clyde T. Foster, president of Ohio Standard, has been elected a board member for one year.

GEORGE W. GUTEKUNST, C. H. Rieman, and Brice D. Maddox have been elected vice presidents of Gardner-Denver Co., Quincy, Ill., manufacturer of compressors, pumps, and air tools.

WILLIAM M. HAILE has been appointed president of Linde Co. division of Union Carbide Corp.

JAMES J. GLASCO has been appointed manager of the tax department of Socony Mobil Oil Co., Inc., New York, N.Y.

FRED W. MacFARLINE, former maintenance supervisor for Great Northern Oil Co., has joined The Vickers Petroleum Co. Inc. refinery, Potwin, Kans., as chief refinery engineer.

RAYMOND S. GIBSON has been promoted to the newly created post of senior process engineer at the Potwin, Kans., refinery of The Vickers Petroleum Co.

ROBERT M. BRINEY has been appointed president of Haynes Stellite Co. Division of Union Carbide Corp.

LLOYD C. GARRIES has been made area manager in Saskatchewan of Core Well Ltd., Canada, with headquarters at Weyburn.

DONALD J. SMITH, president of American Oil Co., retired June 24, after 41 years' service. American is a subsidiary of Standard Oil Co. (Indiana).

EARL G. ELLERBRAKE has been appointed a petroleum transportation and storage specialist in the Office of Oil and Gas, US Department of the Interior. Prior to entering federal service, Mr. Ellerbrake's professional career was spent in the oil industry with The Standard Oil Co. (Ohio) and its subsidiary, Sohio Pipe Line Co.

THOMAS T. ARDEN succeeds John A. Robertshaw as president of Robertshaw-Fulton Controls. Mr. Robertshaw becomes board chairman.

C. J. HELMERS has been promoted to assistant manager of the process development division of Phillips Petroleum Co.'s research and development department, and of application research work previously done in the hydrocarbon conversion branch of the research division. W. N. Axe has been promoted to succeed Mr. Helmers as manager of the hydrocarbon conversion branch.

JULIAN W. QUINN and James A. Perkins, Jr., after 23 years' service with Houston division of Gulf Oil Corp., have formed the firm of Perkins and Quinn, petroleum engineering consultants, Houston, Texas. While with Gulf, Mr. Quinn served as assistant chief petroleum engineer, and Mr. Perkins as chief petroleum engineer for the Gulf Coast district.

MONROE J. RATHBONE, president of Standard Oil Co. (New Jersey), has been named president of the Lehigh University board of trustees, succeeding Eugene G. Grace, resigned.

JESSE D. WINZENRIED has been appointed assistant to President Glenn E. Nielson of Husky Oil Co., Cody, Wyo. Since April 1956 Husky's administrative coordinator, Mr. Winzenried in his new assignment will fill the post left vacant last October when Maurice E. Smith (formerly Mr. Nielson's assistant) became vice president for finance.

FRED S. SCHWEND, formerly LPGas vice president, has been made vice president in charge of several service departments and certain affiliated companies of Warren Petroleum Corp., Tulsa, Okla. These include administration of Warren's personnel, purchasing, marketing research, and tax departments. Kenneth T. White becomes general manager of LPGas division, succeeding Mr. Schwend.

H. R. WALL, Houston, has been promoted to the new position of general manager of Continental Oil Co.'s transportation and supplies department—with headquarters in Houston—succeeding T. A. van Griethuysen, except for purchasing operations. Mr. van Greithuysen recently was named president of Continental Oil Co. of Venezuela.

W. F. (Bill) HAND has been named manager of crude-oil purchasing for Canadian Husky Oil Ltd., replacing J. A. Cameron who left Husky to become assistant general manager—marketing for Prairie Pipe Manufacturing Co. Ltd. of Regina, Sask. As manager of crude-oil purchasing, Mr. Hand will be responsible for procuring crude supplies for Husky's three refineries.

J. A. VICKERS, president of The Vickers Petroleum Co., Inc., was elected chairman of the Governor's Oil Advisory Committee at the group's initial organizational meeting, June 17.

G. H. NAYLOR has been made assistant to the comptroller of Magnolia Petroleum Co., Dallas, Texas to coordinate the staff departments of methods research, data processing procedures, and tabulating departments. Accounting personnel training will also be his responsibility.

J. A. VICKERS, president, The Vickers Petroleum Co., Wichita, has been commissioned by Governor George Docking to serve on the Governor's Oil Advisory Committee for the state of Kansas. Mr. Vickers was recently elected a vice president of the Western Petroleum Refiners Assn. at the group's 45th annual meeting in San Antonio, Texas. Mr. Vickers is also a vice president and director of the Mid-Continent Oil and Gas Assn., a director of the Independent Petroleum Assn., and a director of the Kansas Independent Oil and Gas Assn.

KAREL H. BEEKHUIS has been elected president of Aramco Overseas Co., wholly-owned subsidiary of Arabian American Oil, with headquarters in The Hague, The Netherlands. Mr. Beekhuis formerly was executive vice president of Aramco Overseas, which provides purchasing, shipping, engineering, and other services for its parent company.

P. L. Smith

R. C. Adam

P. L. SMITH has been appointed general manager of the refining division of Magnolia Petroleum Co. At the same time a number of other promotions were announced by R. G. Sanders, who became a director and vice president of refining following the retirement of John W. Newton on May 1.

F. M. Graves was named assistant general manager of refineries, and R. C. Adam was made manager of operations at Magnolia's Beaumont, Texas, plant to succeed Mr. Smith. W. M. Bradshaw was named executive assistant. Mr. Graves formerly was executive assistant, and Mr. Adam was manager of technical services.

Mr. Smith was manager of the Beaumont refinery technical department for 17 years prior to his appointment as manager of operations on January 1, 1956. Mr. Graves is a veteran of 22 years with Magnolia. He entered the company's laboratory in 1935, and was made assistant chief chemist in 1939. Mr. Adam was chief process engineer in the technical department prior to his 1956 appointment as manager of technical services. Mr. Bradshaw has held various positions at Beaumont since he joined the company in 1921.

H. C. Hose

W. M. Bradshaw

H. C. HOSE has been named a director and executive vice president; H. B. Nichols, senior vice president, and G. R. Ferguson, a vice president of California Texas Oil Co. Ltd. R. E. Ludt was named as executive assistant to the board chairman.

G. R. Ferguson

R. E. Ludt

Karel H. Beekhuis

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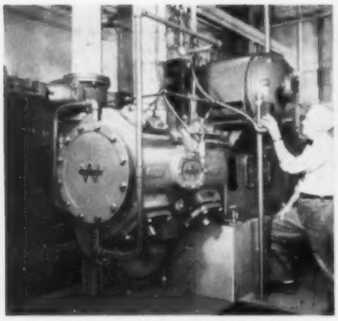
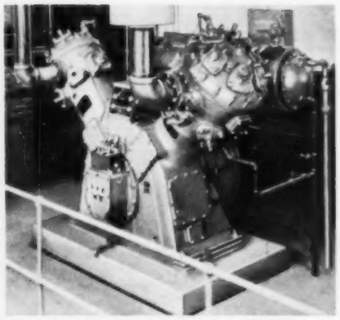
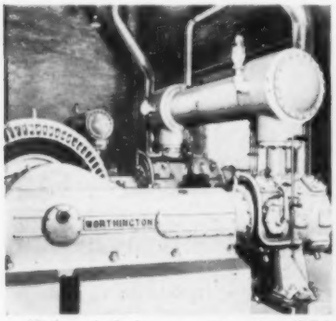


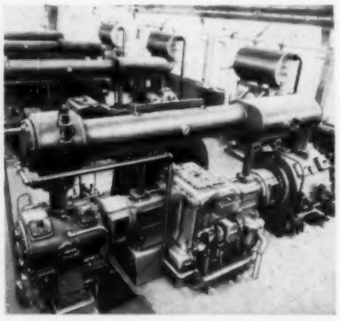
Single-stage compressor, type HB. For economical, continuous supply of air in smaller quantities. Sizes range from 10 to 125 hp. (Bulletin L-640-B1C)



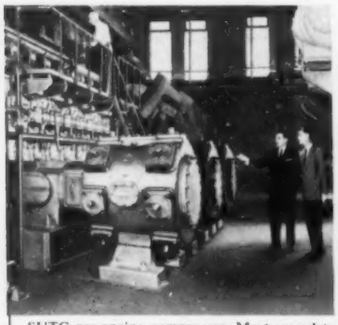
Two-stage angle compressor, type YC. Most compact unit for its capacity. Available up to 250 hp., and in larger sizes in similar type DYC. (Bulletin L-676-B1A)



Horizontal duplex compressor, type DC-2. A two-stage compressor designed for heavy-duty service. From 250 to 3,000 hp. (Bulletin L-675-B1B)



Balanced opposed compressor, type BDC. Versatile—ideal for either multiple or single-service applications. Sizes from 300 to 10,000 hp. (Bulletin L-679-B1)



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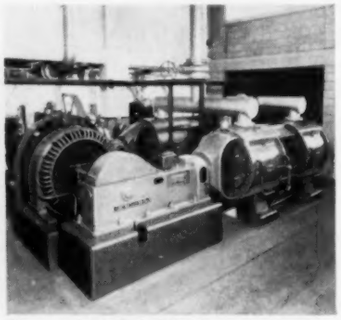

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WORTHINGTON

The sign of value around the world

Washington

By Joseph B. Huttlinger

Major legislation affecting USA oil firms operating abroad will be up for attention of Congress next year, as a result of oil-for-Europe hearings this year. No legislation can come this year because of lack of time.

The staff of two Senate subcommittees, which held joint hearings, has called for a number of studies and actions of widespread impact on USA oil firms operating abroad. Senator Joseph C. O'Mahoney (D., Wyo.) is chairman of the subcommittees.

Five Major Studies

Up for study will be the depletion allowance for foreign operations, tax credits for payments to foreign governments; USA registration of contracts and agreements with foreign governments; antitrust immunity for oil companies—specifically to curb imports and construction of a new oil line through Turkey; and antitrust aspects of major oil-company ownership of pipelines in the USA.

The staff of the two Senate subcommittees which held joint hearings has called for study of legislation to remove the 27½% income-tax depletion provision for crude-oil and natural-gas production outside the United States. While there is argument as to the effect this would have, if any, statistics are available to indicate this would cost Arabian-American Oil Co., for one, an extra $63 million a year, on the basis of 1956 earnings and production.

Staff reports, which were made public during June, also suggest Congress study the 50-50 deals between oil companies and foreign governments, when they serve to reduce income taxes due to the United States.

In the case of Aramco, the company would have owed the USA $176,547,181 in taxes in 1955 but for a Saudi Arabian tax decree of 1950. Under the decree, Saudi Arabia claimed half Aramco's profits, much of them as an income tax. Under a US Treasury Department decision, the payments to Aramco are income taxes, and thus are a direct credit against income taxes due the USA.

The staff also suggested the Department of Justice study Aramco from the standpoint of Sect. 7 of the Clayton antitrust act, and the US Supreme Court decision in June in the case of General Motors and Du Pont. Here, the high court ruled that the government can move to undo mergers by stock acquisition, even when the acquisition was some years back.

Congress also is asked to study legislation to require oil and other firms operating abroad to register all contracts and agreements made with foreign governments with the USA. Along this line, the staff report pointed out there are 14 agreements between the government of Iran and the consortium of oil com-

PIPE LINE

panies operating there which have not been made public. Presumably, registration would mean the agreements also would be available for public reference.

Homefront Operations

The staff suggested the Department of Justice study several matters, brought up in the hearings. One is of "monopolization" in oil pipelines in the USA to see if producers are denied an outlet for crude oil, and whether independent refiners are denied a supply of crude at fair prices. DJ also is asked to study new legislation to make oil-company buying of pipeline stock a clear case of antitrust violation, and to examine whether major oil companies should be asked to dispose of some or all stock in oil pipelines obtained in the past.

Congress, further, is asked to study all grants of antitrust immunity to oil companies, and to determine whether any such immunity should come only from the Congress—not the executive branch of the US government. Examples named were immunity given the Middle East Emergency Committee, National Petroleum Council, Iranian consortium, US oil conservation, and agreements alleged in the government's broad complaint in the alleged "oil cartel" case now in the US courts.

Turning to more current matters, the staff has suggestions regarding possible action in Washington to limit the flow of crude imports to the USA, and efforts of five USA oil firms and three foreign for joint ownership and operation of a large pipeline from Iraq, through Turkey, to the Mediterranean Sea. The line would carry 1,200,000 b/d.

On the matter of oil imports, the staff sees the prospect of antitrust immunity being asked and given oil importers to "agree" on volumes to be brought in. As to this, the staff objects "any waiver of the antitrust laws," it says, "should come only from Congress."

Regarding the crude pipeline, the staff sees a bona fide need for it, but suggests the US government, rather than independent oil companies, should "work out" and "authorize" the action, under specific action by Congress.

The staff reports were made public after Senator O'Mahoney found difficulty in winning agreement on a report which could be offered as from the subcommittees themselves. The effort for a formal report of the subcommittees continues.

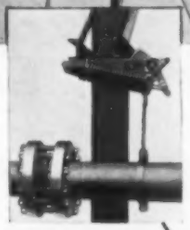
The staff reports, which reportedly have the wholehearted support of Senator O'Mahoney, are at odds with the findings of the House Commerce Committee, which also studied the oil-for-Europe program. This committee, under Representative Oren Harris (D., Ark.), reported the program was a "stupendous" success. About the only thing the Harris group asked for was an effort to limit crude imports to the USA. END

Photograph by courtesy of The Associated Ethyl Company Limited.

VOKES GENSPRING pipe hangers are used throughout the oil industry

At their Ellesmere Port Works in Cheshire, The Associated Ethyl Company Limited have made use of VOKES GENSPRING Variable Support Pipe Hangers to control movement which could set up very great stresses in the piping. 'Shell' have also incorporated VOKES GENSPRING hangers throughout the Platforming Unit at their Stanlow Refinery in Cheshire.

Photograph by courtesy of 'Shell'.



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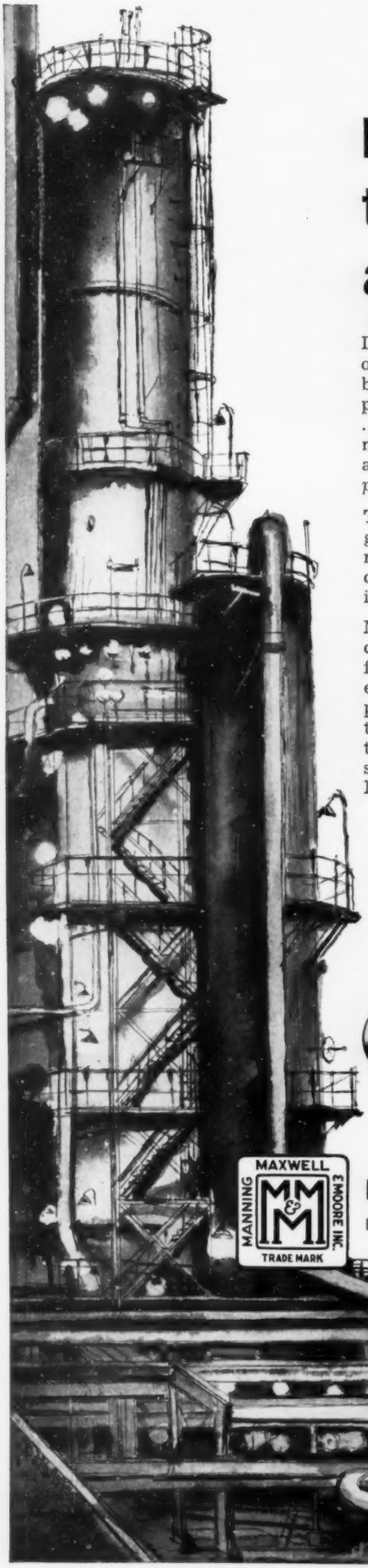

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Demand abroad by the petroleum industry for our industrial instruments and valves is now being met by manufacturers well-known for precision and quality production. These licensees . . . in England, France, Belgium, Western Germany, and Italy . . . help to assure global availability of these products and make it possible for *payment to be made in local currency.*

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Consolidated "Electromatic" Relief Valves
Hancock 800# Type 950 Steel Gate Valves

IN FRANCE

SAPAG, Paris
Consolidated Safety Relief Valves
Hancock 1500# and 2500# Steel Valves
Hancock 800# Type 950 Steel Gate Valves
Hancock Steel "Flocontrol" Valves

IN BELGIUM

Ateliers Jaspar, S.A., Liege
Consolidated Safety and Safety Relief Valves

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Consolidated Safety Relief Valves
Consolidated Safety Valves
Consolidated "Maxiflow" Safety Valves
Consolidated "Electromatic" Relief Valves

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Consolidated Safety Relief Valves
Hancock Temperature Regulators
Filotecnica Salmoiraghi—SPA, Milan
Ashcroft Duragauges
Ashcroft Pneumatic Transmitters

IN CANADA

Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Ashcroft Gauges
Consolidated Safety and Safety Relief Valves
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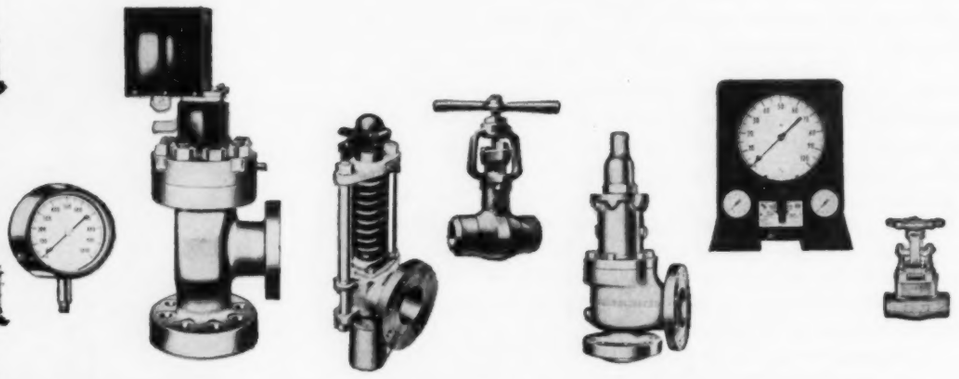

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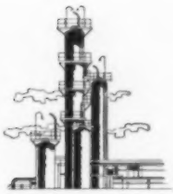

How is your expansion program doing? Has it been delayed? Is it scheduled to begin soon? Regardless of the time factor, Parsons' Technical Planning Services* plus design†, procurement and construction are available to Industry and Government *with the future in mind.* By taking advantage of these services *now*, your facilities will be ready—when you want them—where you want them—the way you want them—to put you *one step ahead of the field.*

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†*Process, Mechanical, Electrical, Structural, Civil and other engineering services.*

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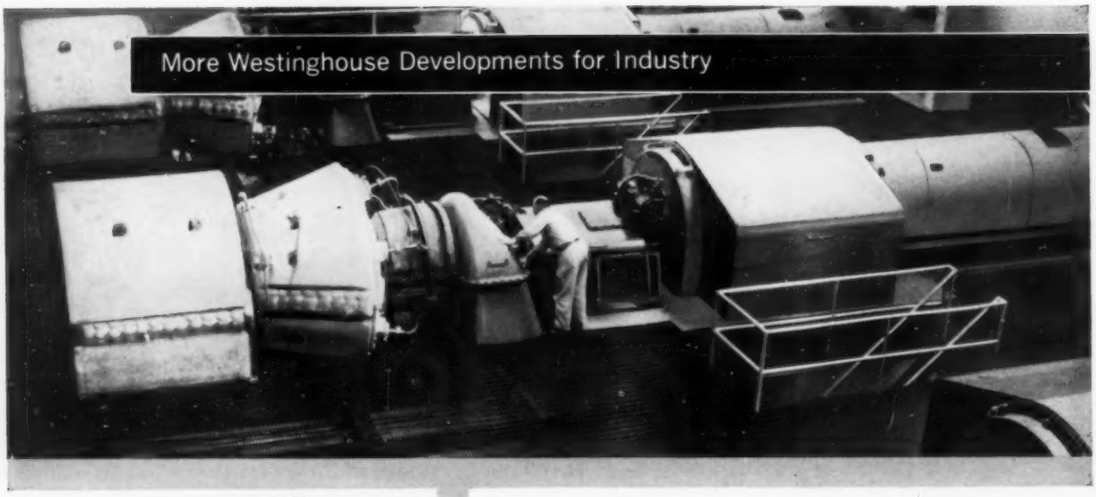
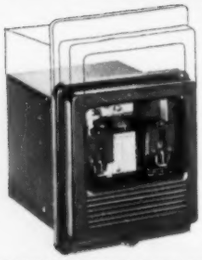
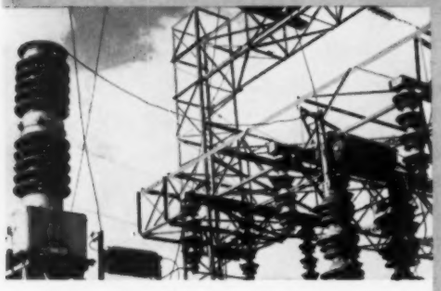




NEW RELAYS SAVE PANEL SPACE

New from Westinghouse—a completely redesigned line of protective relays that require less panel mounting space, yet provide more efficient and dependable operation. Housed in cases one-third smaller than previous designs, they also provide easier accessibility for settings and adjustments. Request "Book J."



POWER-LINE CARRIER "TRANSISTORIZED"

The first completely transistorized power-line carrier assembly was installed recently by Westinghouse for protective relaying. Promising many important advantages, transistorized equipment is smaller, easier to handle (cases of less than ½ cubic foot replace cabinets of more than 17 cubic feet). It effects large savings in station battery power, while long-lasting transistors eliminate most maintenance costs.

This gas turbine runs without a drop of water

Advanced design Westinghouse gas turbines offer you the most practical lightweight, quick-starting prime mover available—*one that can be run without a drop of water.* A special radiator makes the ordinarily required cooling water supply unnecessary. Available in capacities from 3250 hp (2250 kw) to 22,000 hp (16,500 kw), vibration-free Westinghouse gas turbines require only light foundations and absolutely no base plate. This saving on installation in the cost of labor, materials and time, is one more reason for specifying Westinghouse gas turbines. Request "Booklet H" for complete details.

For more information on any of the developments shown here, or for help on your specific engineering problems, write to Westinghouse, Box 345, Wall Street Station, New York 5, U. S. A.

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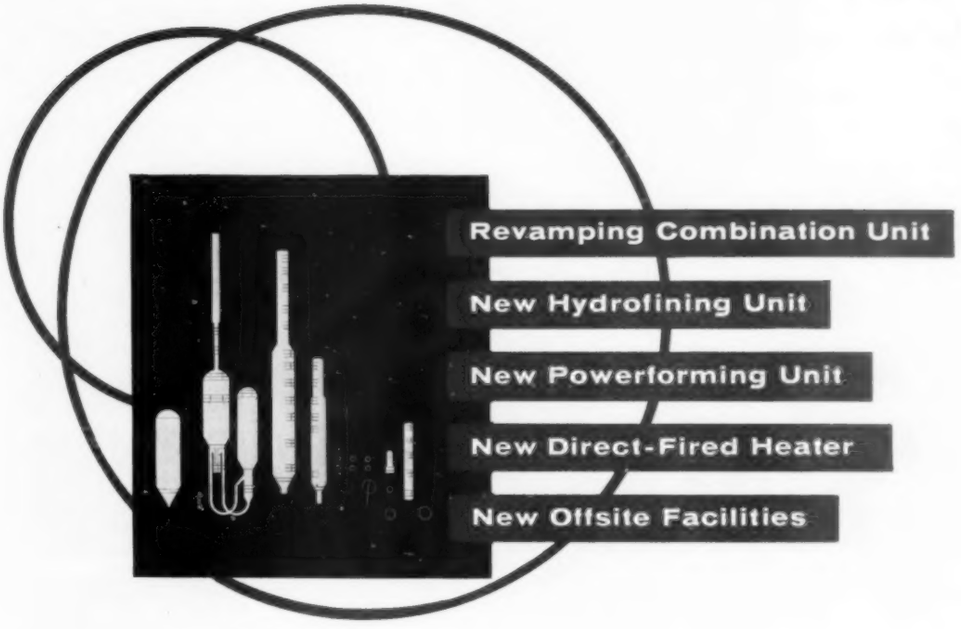

Foster Wheeler Corporation, builder of the original Durban refinery for Standard-Vacuum Refining Company of South Africa, Pty. Ltd., will design and construct all major process units for this expansion project. The new units and revamping of existing facilities will improve both quality and yield of the refinery's full range of fuel products and asphalts.

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DU PONT *Petroleum Chemicals* NEWS

Number 77 in a Series of Bulletins for the Petroleum Industry

JULY 1957

Sludge problems in residual fuels minimized by Du Pont additive

ASSISTANT GENERAL MANAGER . . . ORCHEM

DR. WILLIAM C. KAY is Assistant General Manager of the Organic Chemicals Department of the Du Pont Company.

He started work with Du Pont as an industrial engineer at the Chambers Works in 1934. He became project engineer in 1939, and joined the neoprene manufacturing organization as chief supervisor in 1941.

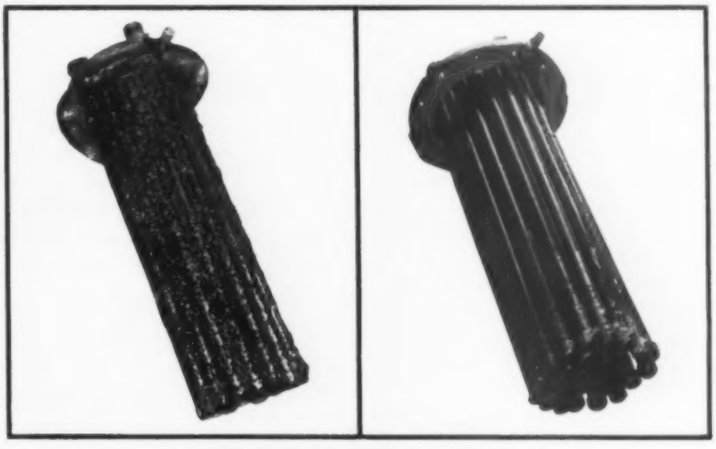
In 1943, Dr. Kay was assigned to the atomic project at Oak Ridge, Tennessee, as production superintendent. From there, he moved to the Hanford Works plutonium project in Washington. He was named Process Manager of the Du Pont Grasselli Chemicals Department in 1947.

Dr. Kay in 1950 joined the Explosives Department as Director of Manufacturing for the Atomic Energy Division. He assumed the same position in the Organic Chemicals Department in 1955. His appointment as Assistant General Manager occurred at the beginning of this year.

Dr. Kay earned his B.S. and Ph.D. degrees, respectively, at the University of Minnesota and M.I.T.

Sludge-packed systems cleaned and KEPT clean

It is, of course, a well-known fact that residual fuels too often cause serious problems. Being the "bottom of the petroleum barrel," they contain, in concentration, all the impurities from the lighter oils which have been distilled off.



PREHEATER TUBE-FOULING . . . solved by FOA-2

TO REVIEW THE PROBLEM . . .

Insoluble sludge is likely to form in residual fuels—in storage, in transit or in use. That, briefly, is problem No. 1.

Problem No. 2: Residual fuels, when blended, are often incompatible. Insoluble sludge is likely to form.

Du Pont Fuel Oil Additive No. 2 solves both problems.

Sludge cure

When sludge forms, trouble starts in the form of clogging. Many times nothing short of costly major "surgery" will start the oil flowing. So tank walls are cut through, sludge is removed mechanically, and the hole is patched up.

Oftentimes it is found that fuel system parts, filters, strainers, nozzles, preheater tubes and shells, have become clogged. While mechanical cleaning sometimes restores their functions, expensive replacements are sometimes necessary.

With these corrective measures going on, *downtime* is mounting, and labor costs are keeping pace.

Many other residual fuel users know that such an operation isn't necessary, that FOA-2 would have cleaned the tanks and parts, restored operation of the system. No cutting into tanks, no cleaning or parts-replacement, no heavy labor expense. Downtime? Greatly reduced.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

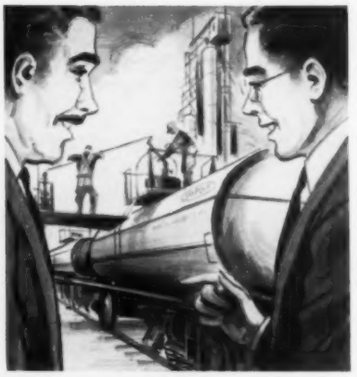
Du Pont is always prepared to meet your emergency TEL needs

REFINERY SUPERINTENDENT:

We're in a jam. Our next regular TEL delivery is not due for another 10 days. But our refinery is gearing up to meet an unexpectedly heavy demand . . . and we don't have enough TEL to do the job.

DU PONT REGIONAL SALES OFFICE MANAGER:

Don't worry about it. We have several tank cars of TEL on a siding only a few miles from here. We can get a couple of cars over first thing in the morning.



REFINERY SUPERINTENDENT:

The TEL cars arrived this morning. That's service . . . less than 24 hours to deliver. It's good to know we can get that kind of service when we need it.

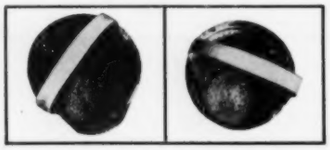
CONTINUED

Sludge problems

How it works

FOA-2 added to residual fuel attacks insoluble sludge, reduces the size of the particles which compose it, suspends them. Thus the fuel flows freely through the system. There is no blockage of nozzles, lines, filters, strainers and other parts. Oil, suspended sludge particles, and the FOA-2 burn completely.

Once a system is cleaned with FOA-2, small amounts of the additive *keep* it clean. That's because FOA-2



STRAINER-PLUGGING . . . solved by FOA-2

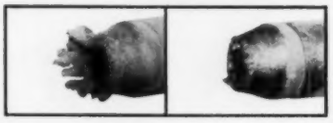
is a stabilizer and solubilizer as well as a dispersant.

FOA-2, being nonmetallic, is ashless and leaves no residue after burning.

Case histories prove power of FOA-2

Early this year we assembled in one technical memorandum ten case histories documenting the power of FOA-2 to clean, and to keep clean, systems fueled by "barrel-bottom" residuals.

We believe you will be interested in the ease and economy of using FOA-2, and suggest that you write for Technical Memorandum No. 317, dated January 1957.



NOZZLE-FOULING . . . solved by FOA-2

Director of Petroleum Laboratory Appointed to NACA Subcommittee

Dr. Bernard M. Sturgis, director of the DuPont Company's Petroleum Laboratory, Deepwater Point, N. J., has been appointed to the National Advisory Committee for Aeronautics subcommittee for aircraft fuels.

Subcommittees of the NACA assist in initiating research programs, advising upon technical problems, reviewing current research throughout the nation, recommending new areas of research, and coordinating research programs. NACA objectives are to anticipate the research needs of aviation and to supply the armed forces and industry with basic information for the design and production of aircraft.

DuPont's Petroleum Laboratory devotes a considerable part of its research effort to aircraft fuels and lubricants.

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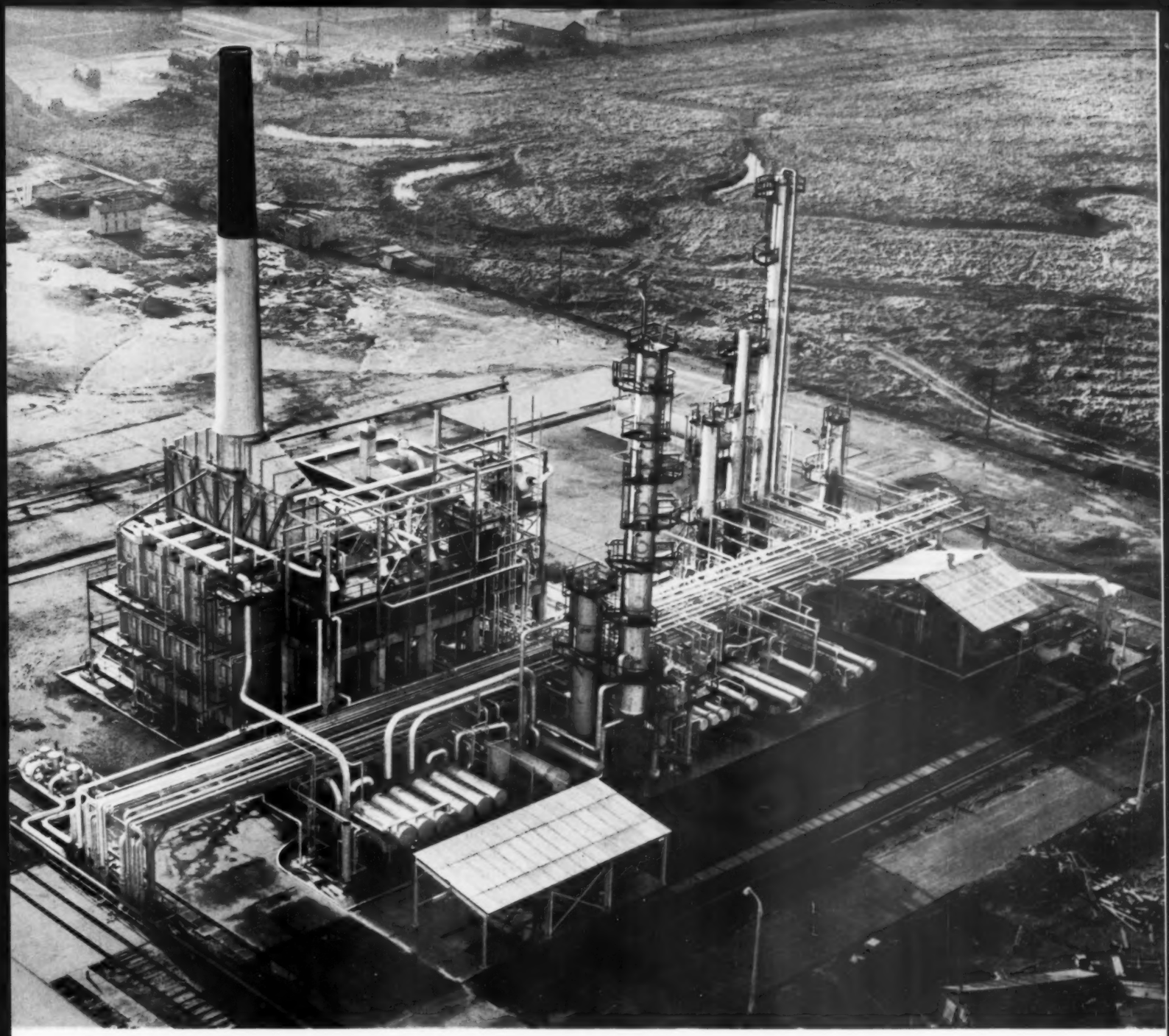

NEW LINK IN A WORLD-WIDE CHAIN

Completion of an expansion program at the Coryton (England) Refinery of Mobil Oil Company Limited, adds another link to the chain of refinery projects entrusted to Bechtel around the world.

Bechtel International Limited engineered and constructed the expansion in association with George Wimpey & Co., Limited.

The Bechtel organization is active in Europe, the Middle East, Far East, North and South America.

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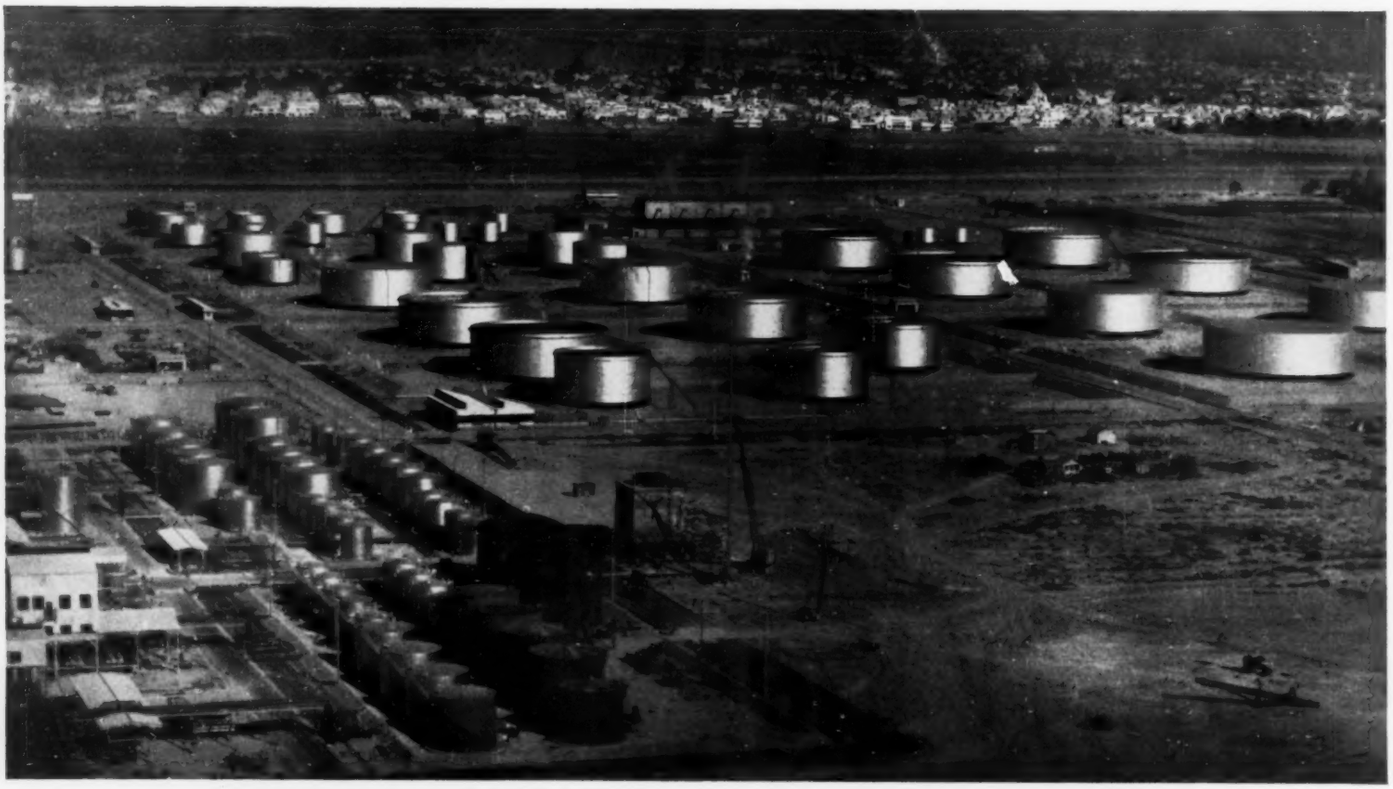

The Iraq Government Refinery at Daura, Baghdad. We supplied the majority of the tanks and erected all of them, including the lubricating oil plant tanks shown in left foreground. The total number of tanks supplied was 120 and tank steel 7847 tons.

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For the convenience of clients, a subsidiary Company has been formed in Baghdad, Iraq, for the fabrication of small steel tanks and vessels, and structural steelwork. The works are also equipped for the overhaul of construction plant and equipment, and general machine shop work. The assembly and testing of plant and equipment shipped from overseas can be undertaken.

Please address enquiries to: Iraqi Steelworks Ltd., P.O.B. 181, Baghdad.

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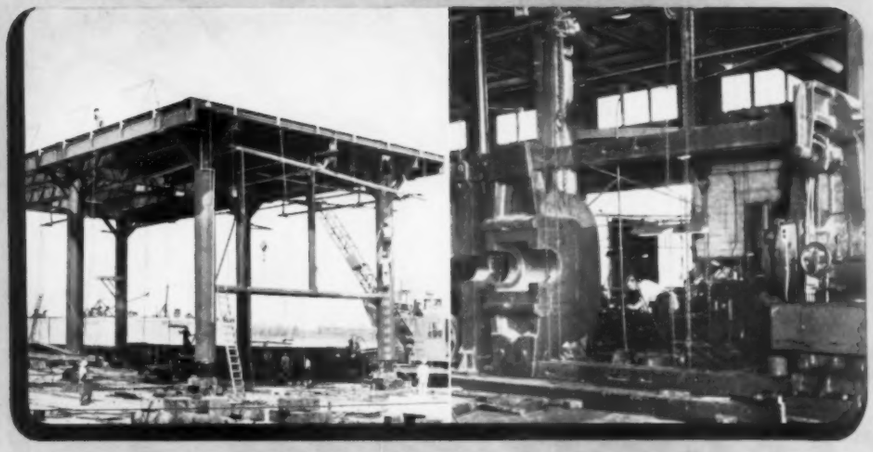

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A map illustrates the fact . . . that in the fan-shaped riches of the Tidelands, there is one centrally-located point for construction and repair. That point is Avondale, with four major divisions compactly grouped in the New Orleans area. Moreover, Avondale has the facilities—the capacities—the special production tools required by offshore operations. For a small job—quick repair of a piece of drilling equipment—there is Avondale's enlarged Oil Field Machine Shop. For the design and construction of an elevated deck drilling barge—a big job in every sense of the word—there are Avondale's vast facilities at the River Plant. Yes, when you want the best and you want it fast, your nearest and most complete source is Avondale . . .

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Timken seamless steel tubing is already in use in several extremely deep or high pressure wells. Results have been highly satisfactory. For more than 24 years we have been making high pressure seamless tubing for many other special requirements.

FREE ENGINEERING STUDY . . . Get your free copy of "Timken Oil and Gas Well Tubing", a study of various alloys for high strength and corrosion resistant tubing, made by Timken Company metallurgists. Write to: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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Collection and recovery of valuable liquid products — removal of liquid particles harmful to subsequent processes — reduced equipment maintenance and decreased air pollution . . . these are but a few of the possibilities METEX Hi-Thruput Mist Eliminators offer to alert process and project engineers.

METEX Hi-Thruput Mist Eliminators, installed in a process tower or vessel, effect sharp separation of entrained liquids within a wide range of vapor velocities. Pressure drop is negligible. Quality and yield are increased. High removal efficiency is maintained, even at extreme temperatures, due to free-drainage of impinged liquids. Liquid slugs cannot enter turbines or compressors. Coke formation is minimized and life expectancy is substantially increased even under adverse conditions.

Where solids may be formed in the mesh because of decomposition, polymerization, crystallization or freezing, METEX Hi-Thruput Mist Eliminators provide up to three times the service life of conventional units.

In any processing equipment or vessel where liquid entrainment is a contributing factor in design or operation, METEX Hi-Thruput Mist Eliminators assure higher production, better processing and lower operating and maintenance costs.

For complete information and specifications, write today for your copy of Bulletin ME-106, illustrating and describing METEX Mist Eliminators for all process equipment.

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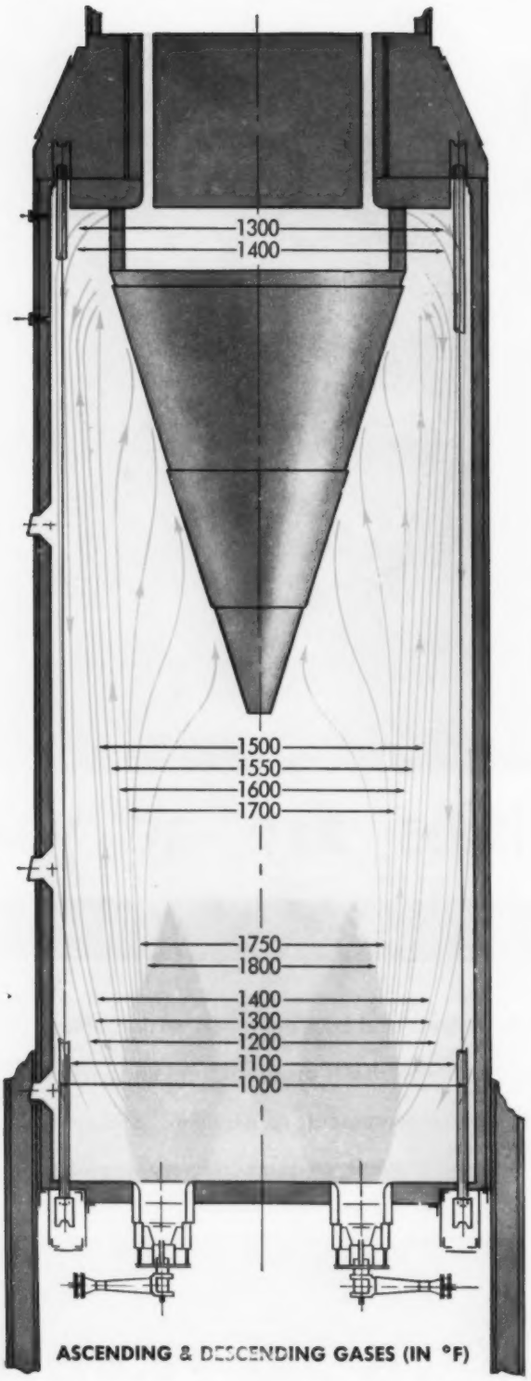


ASCENDING & DESCENDING GASES (IN °F)

Here are the facts!

The first vertical cylindrical heaters provided even circumferential heat input, but vertical flux distribution varied considerably, from high transfer at the bottom of the tubes to low rates at the top. Improvements in design during the past twenty years have overcome this difficulty, by providing proper firebox proportions, a reradiating cone, and burners specifically designed to the requirements of the furnace.

It is significant that *only Petrochem-Isoflow furnaces* incorporate all three of these critical items of design.

The small, hot cone tip reradiates to the tubes, across a considerable distance. Because of the conical shape employed, each higher element of the cone is of larger area, and closer to the tubes than the section below. These factors compensate for decrease in cone temperature from tip to base, provide relatively constant radiant heat transfer over entire upper tube length.

The cone also serves to divert flue gases along the upper ends of tubes, which adds convection heat transfer over this length. It also initiates a high rate of firebox recirculation of combustion products, by cooling the gases in their passage across the tubes.

Being cooler, and therefore heavier than the rising gases in the center of the firebox, the gases adjacent to the tubes fall to the bottom of the heater by thermal siphon effect, increasing the heat input to the rear of the heating elements by convection. The descending gases also serve as a buffer between hot gases and the lower ends of the tubes and dilute the products of combustion. The special burners, by developing a symmetrical flame pattern, contribute to the equality of heat distribution over the entire radiant tube length.

Of the design features mentioned above, the cone is of the greatest significance because it is essential to even radiant heat distribution.

Experienced operators know that even heat distribution improves product quality, decreases tube deteriorations, results in longer, trouble-free operating cycles.

The Data Shown in the Drawings are ACTUAL PERFORMANCE RECORDS!

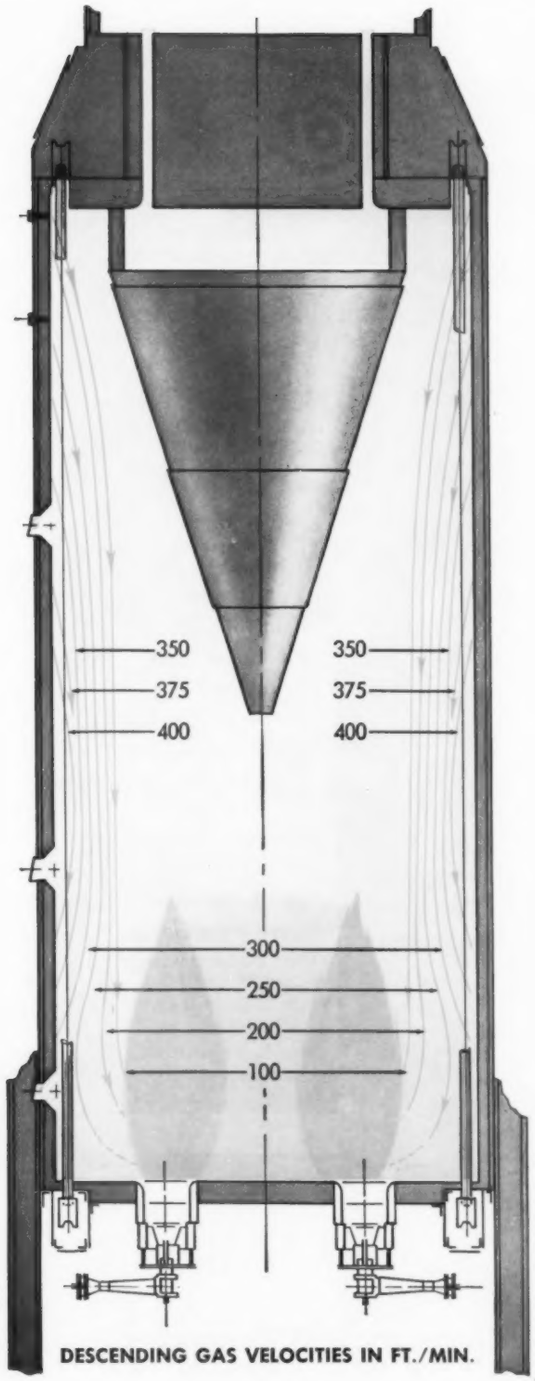
To check radiant flux distribution in Petro-Chem furnaces, exhaustive tests were made under actual operating conditions; some of the results of these tests are indicated in the two adjacent drawings.

Left: Plot of isotherms in a Petrochem-Isoflow firebox, illustrating the uniformity of firebox temperature.

Right: Plot of flue gas flow patterns and velocities, demonstrating the high gas recirculation rates.

Both of these phenomena are the result of proper firebox proportions, the two-fold action of the cone, and symmetrical flame pattern.

Provide EVEN HEAT Distribution !



DESCENDING GAS VELOCITIES IN FT./MIN.

In addition to even heat distribution, other all-important factors which determine the value and efficiency of processing furnaces include:

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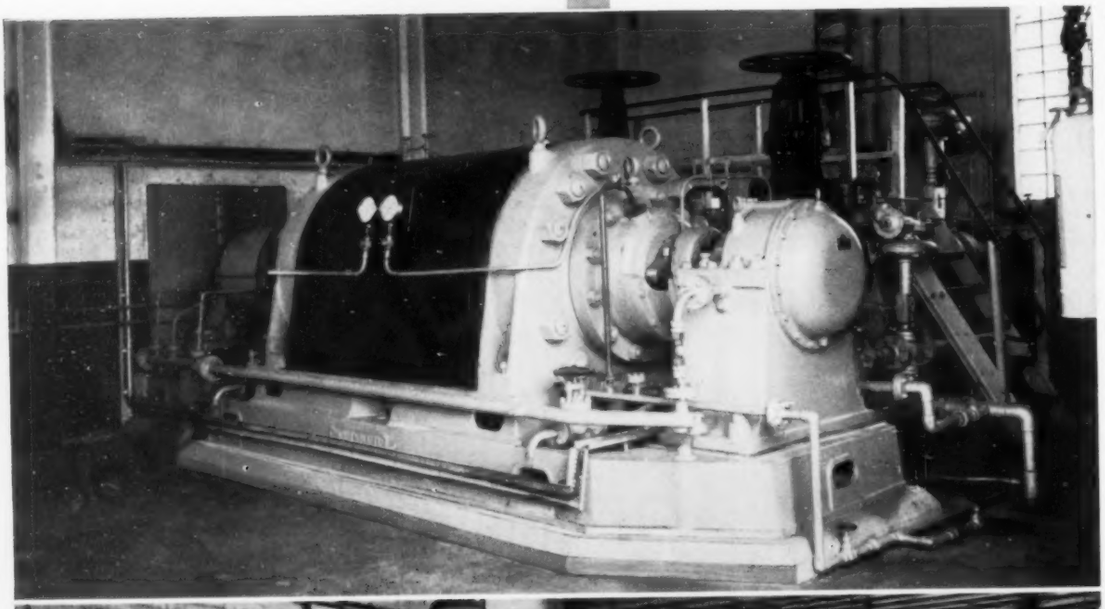
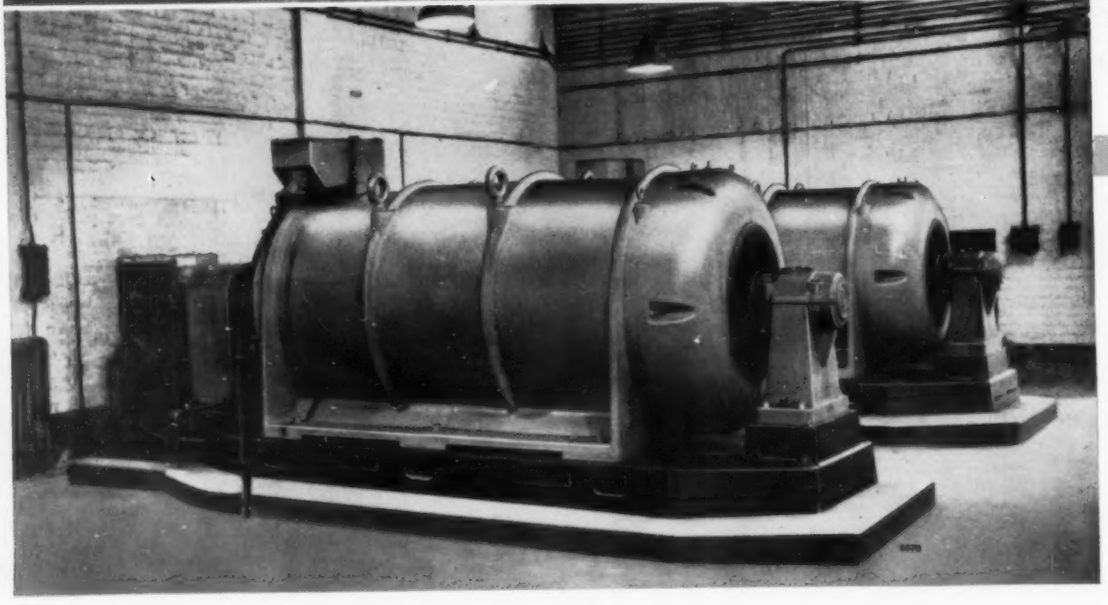


A Mather & Platt Plurovane pump rated to deliver 1760 g.p.m., of crude oil at a head of 2100 feet installed at a Scottish oil pipe-line booster station.



Two 1000 h.p. flameproof motors installed to drive Mather & Platt oil pumps in the famous Oil Pipe Line round Britain.

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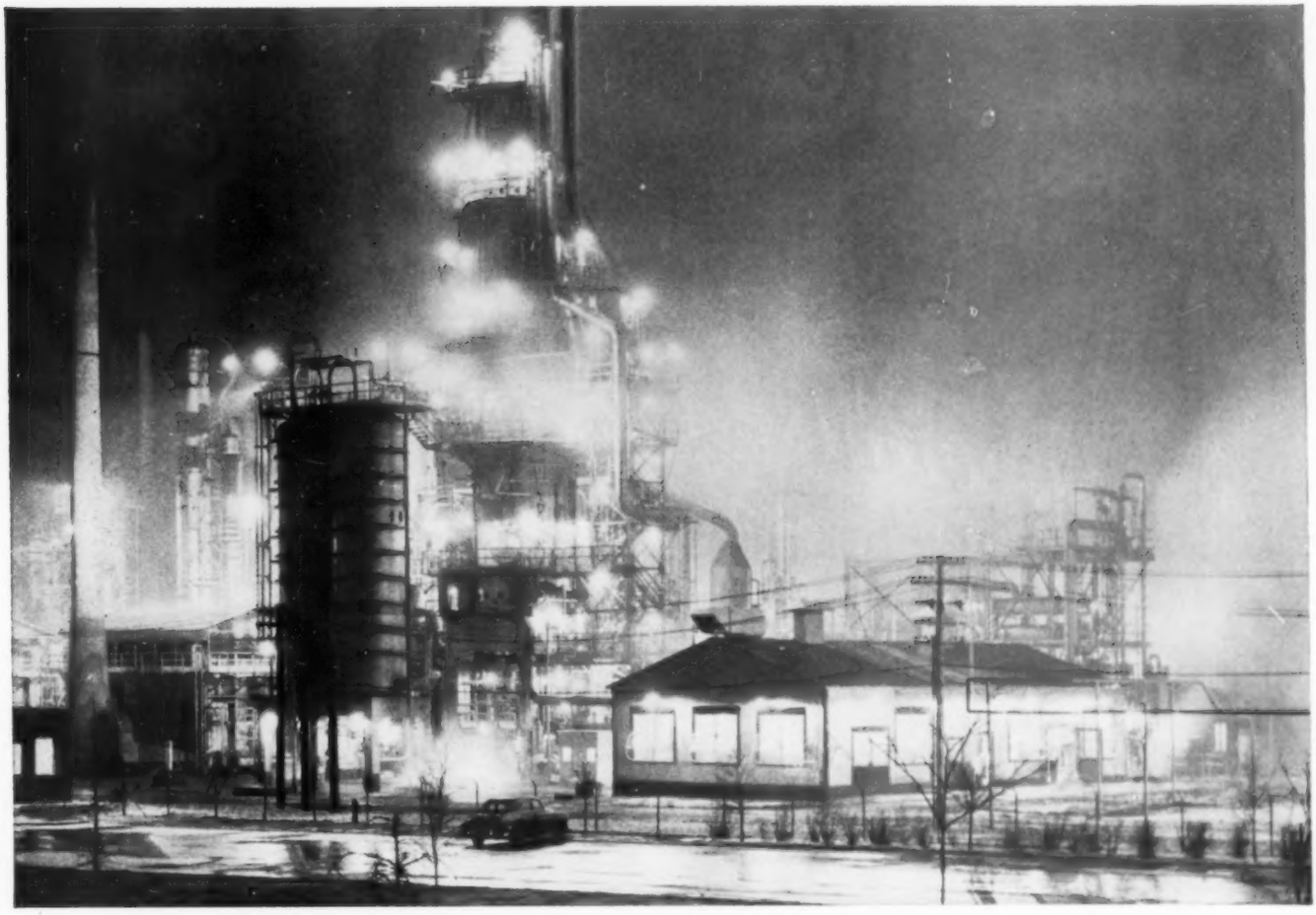

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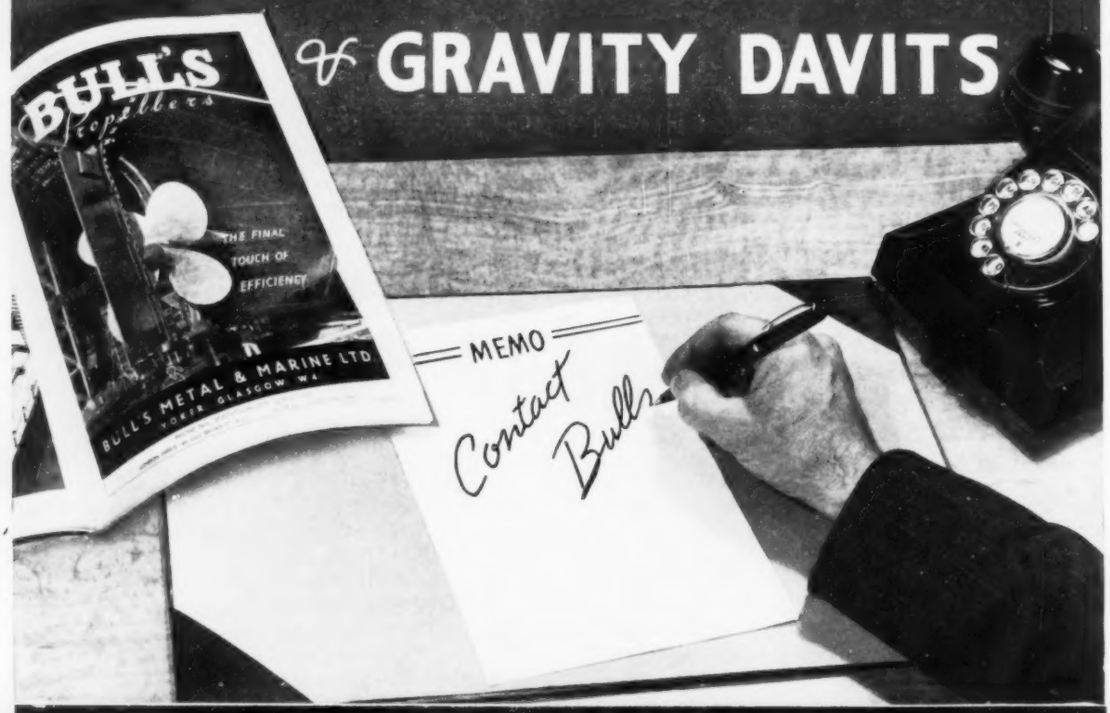

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Fire Hose (neoprene covered)	For highest dependability in fire protection.	MALTESE CROSS	1½" 2" 2½"	400 rated test pressure
Liquefied Petroleum Gas Hose	Bulk Handling	MALTESE CROSS	1½" to 3"	300-250
	Burner	SERVALL	¼" ⅜"	300
	Bottling	MONARCH— (molded & braided)	½" to 1"	350
	Tank Ship	MONARCH TANKER	4" to 8"	250
	Undersea	MONARCH SEA LOADING	4" to 8"	250
	Consumer Delivery	MONARCH— (molded & braided) TWIN LP-GAS	½" to 1¼" ¾" x ½"	350 350
Multi-Purpose Hose	Designed for light, medium, or heavy duty in handling air, water, gasoline, oil, mild chemicals, and other fluids.	SERVALL	¼" to 1½"	300-200
Oil Suction and Discharge Tanker Hose	Designed to load and unload crude oil and refined prdoucts.	MONARCH (smooth bore)	2" to 12"	200
		AJAX (smooth or rough bore)	3" to 8"	150
		CONSERVO (smooth bore)	2" to 8"	100
Steam Hose	Designed to withstand high temperatures and pressures.	MONARCH (glass braided)	½" to 2"	(temperatures 200 to 388°F.)
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Tank Truck Hose	Designed for loading and unloading trucks and trailers that transport gasoline and oil.	MONARCH	1½" to 3"	150-100
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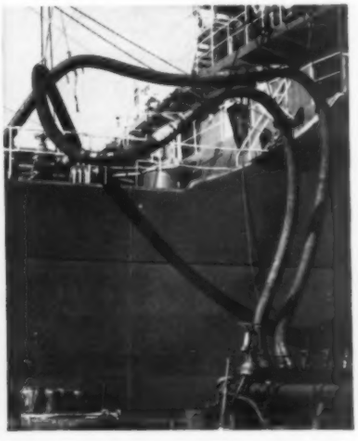

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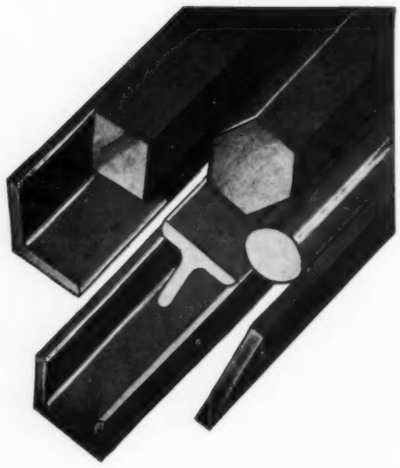

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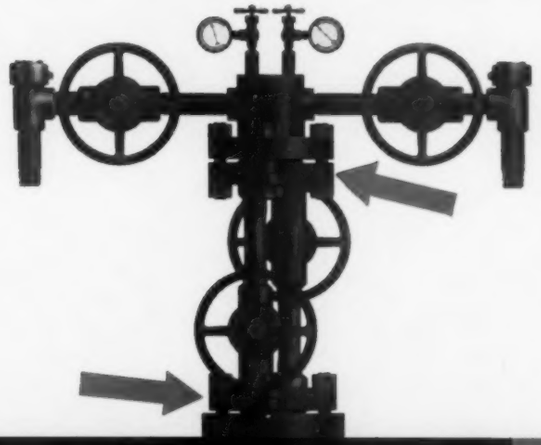

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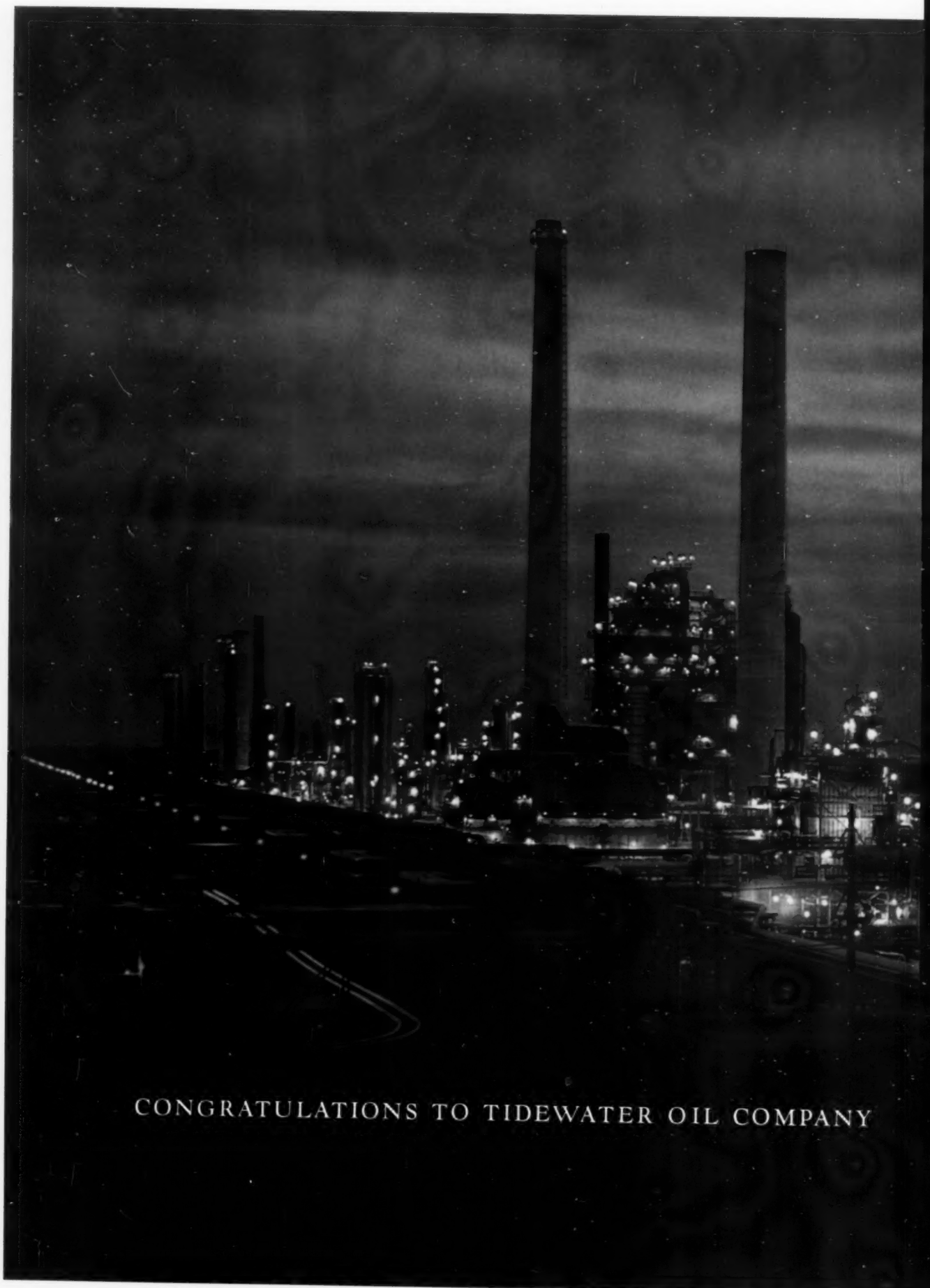
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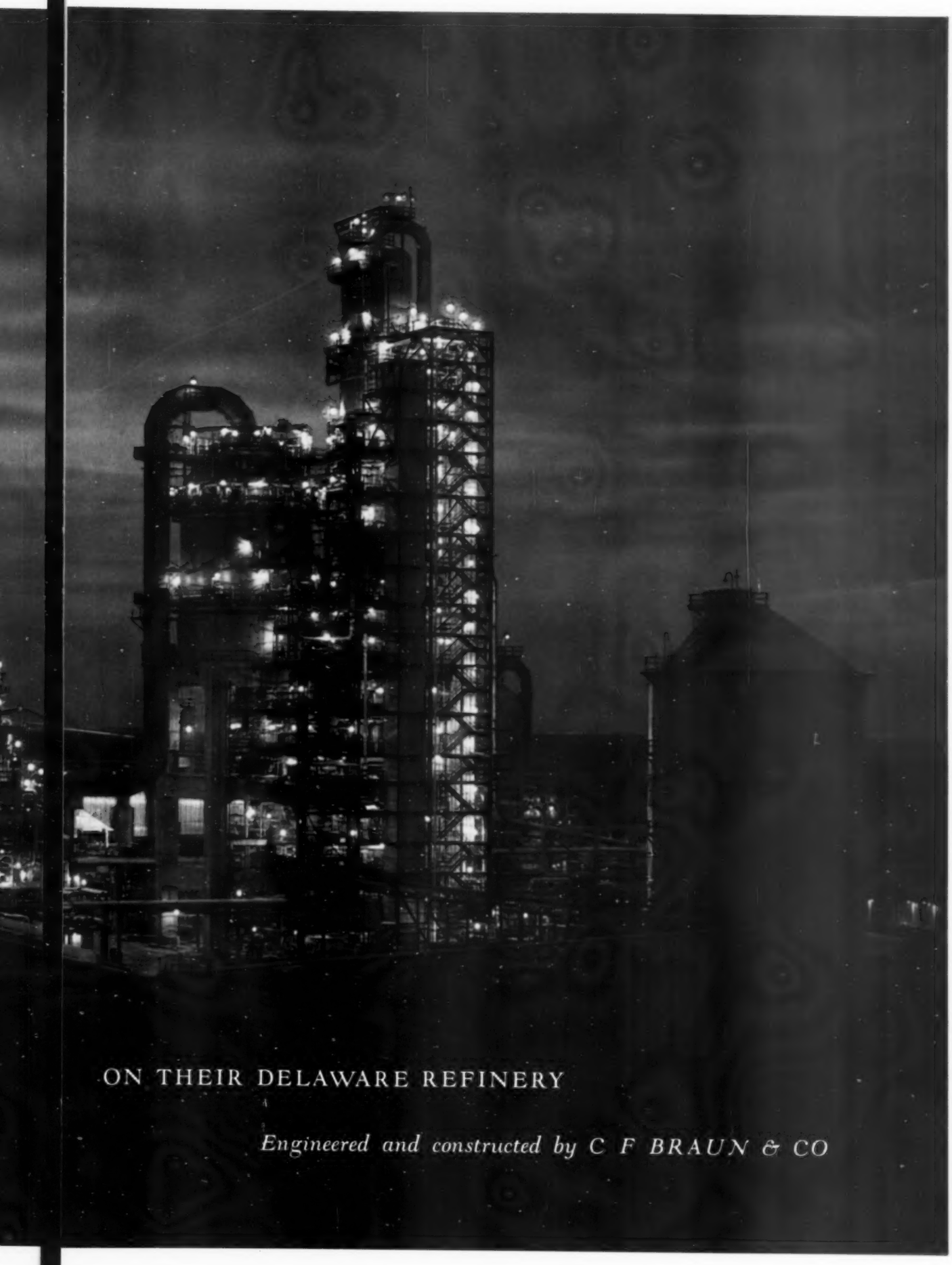

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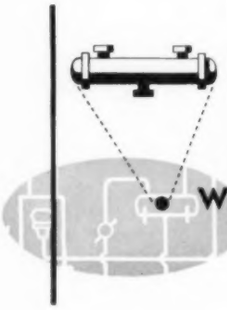

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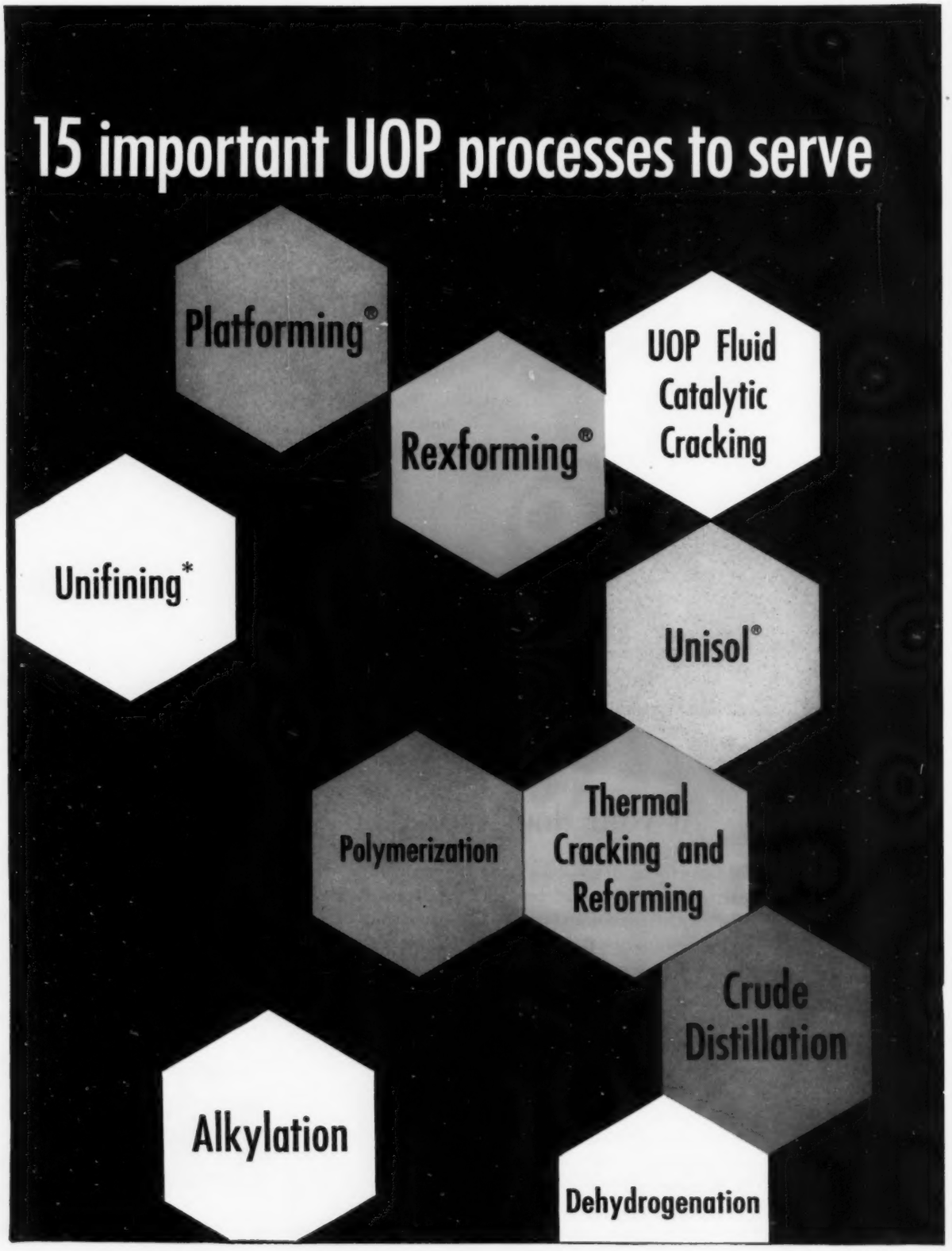
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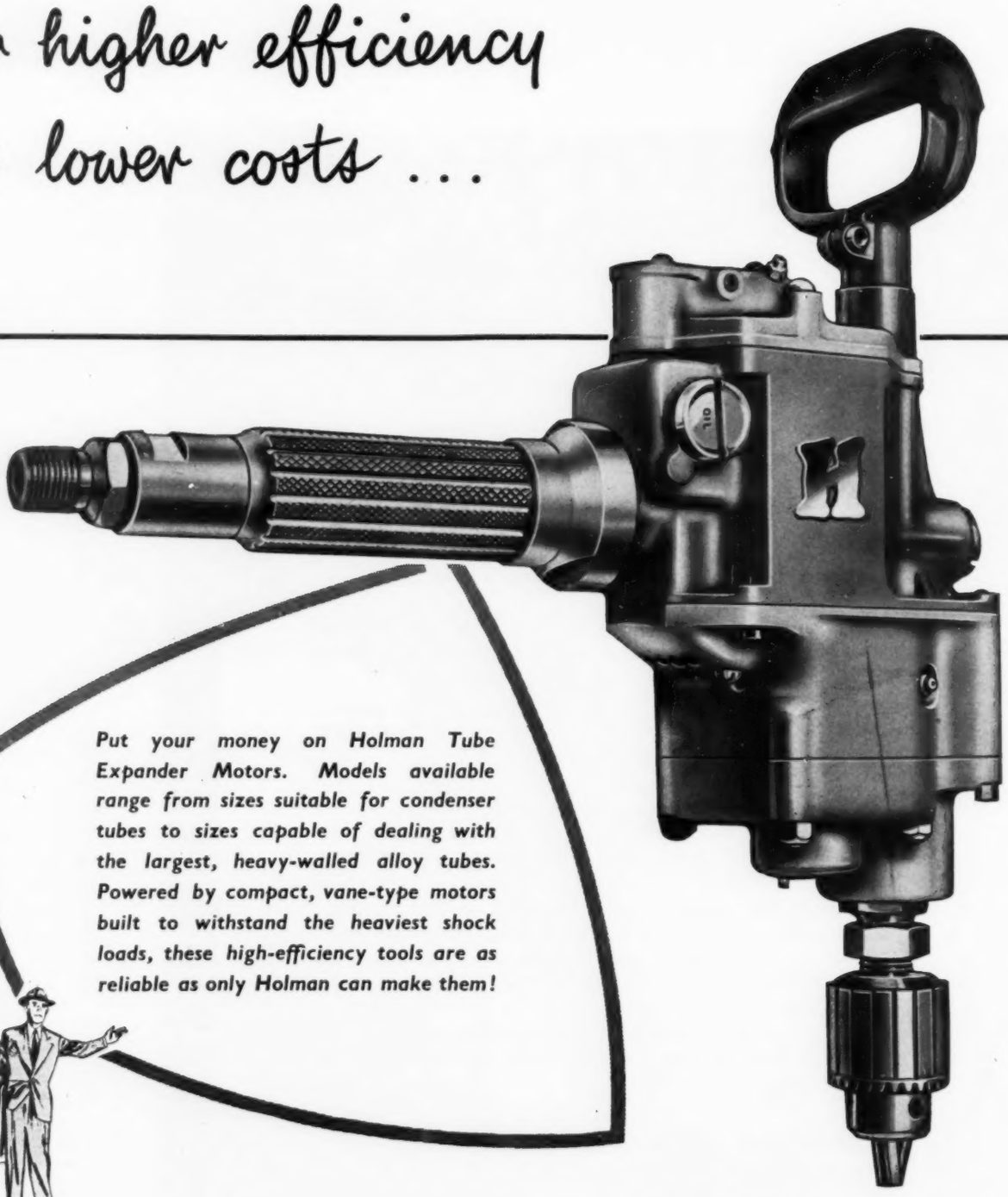

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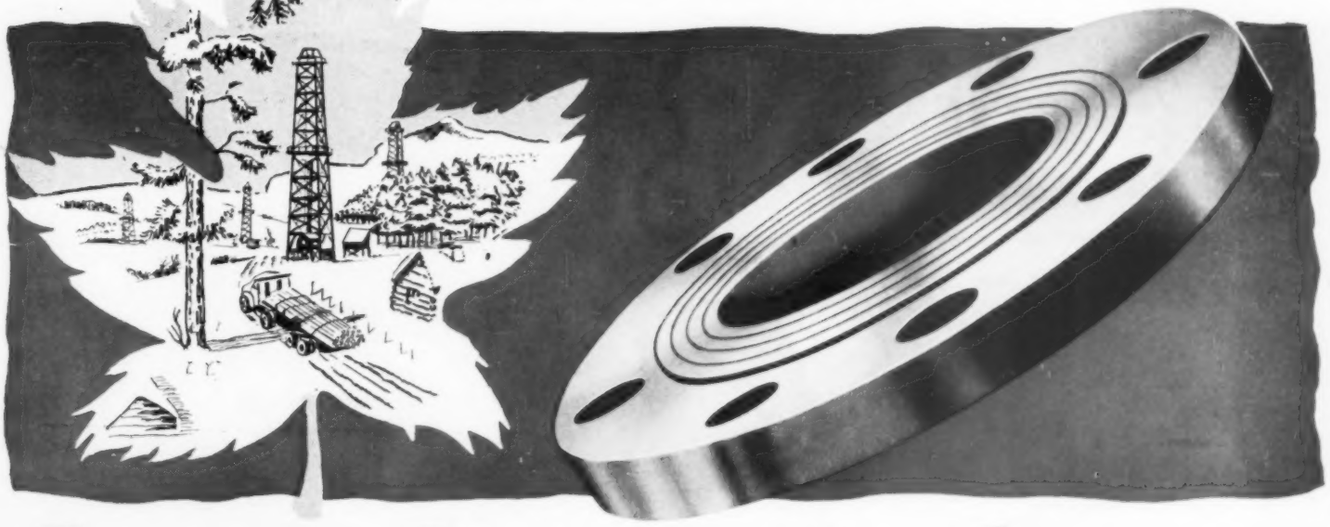

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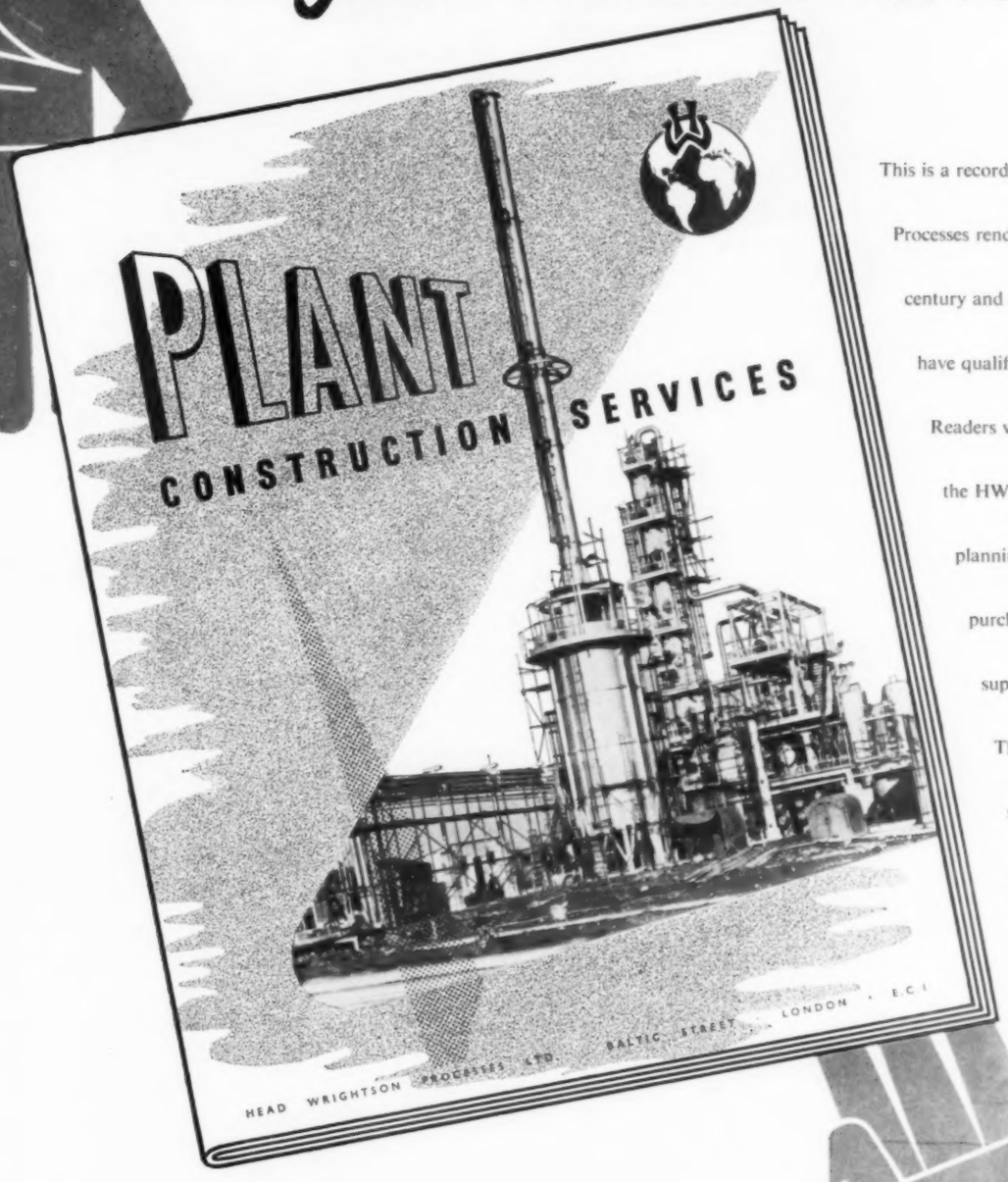

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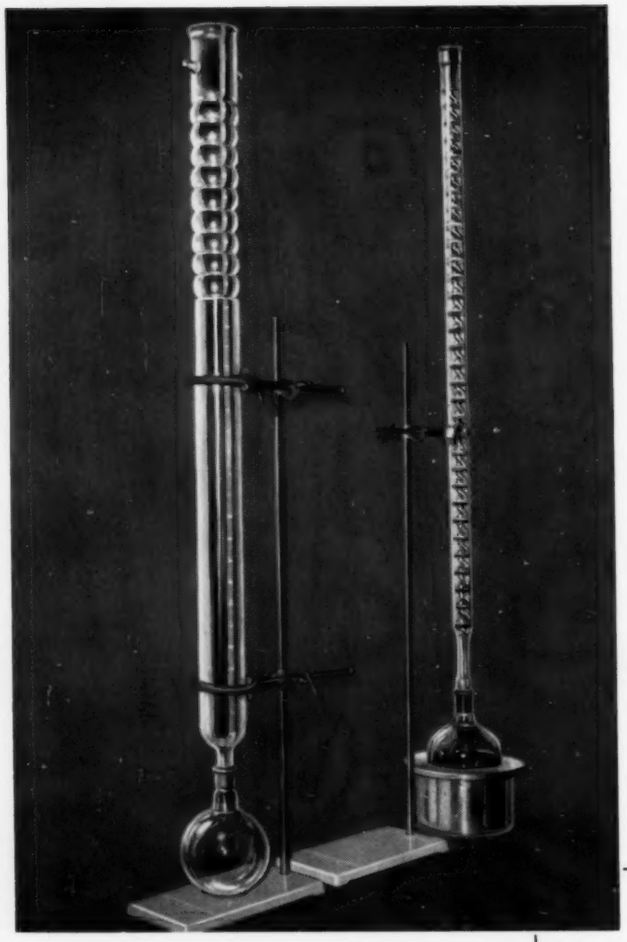

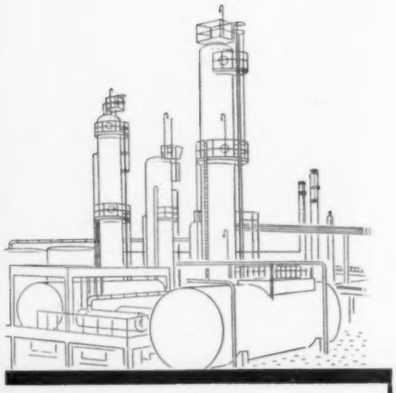

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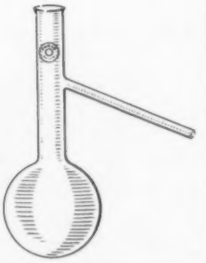

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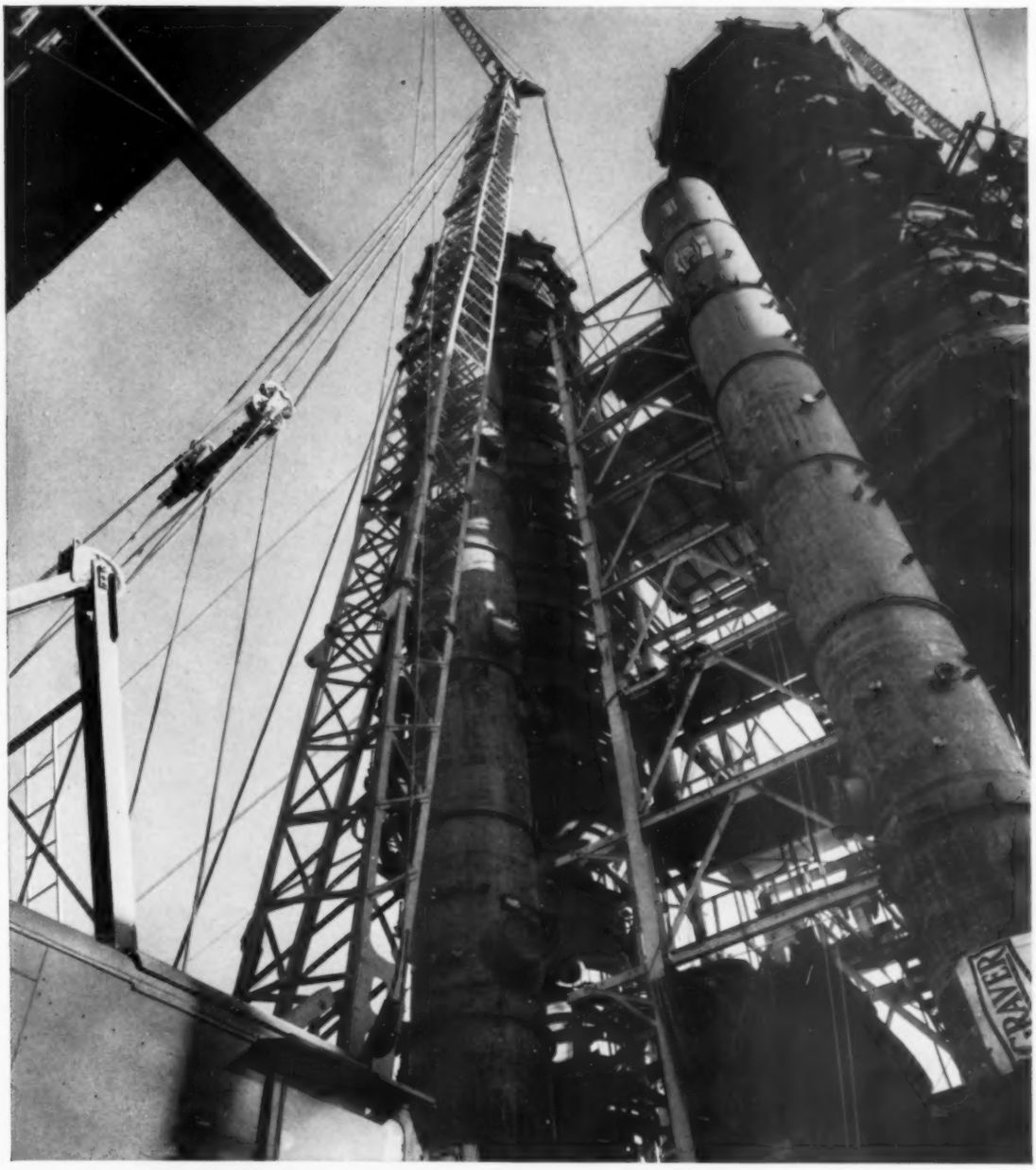

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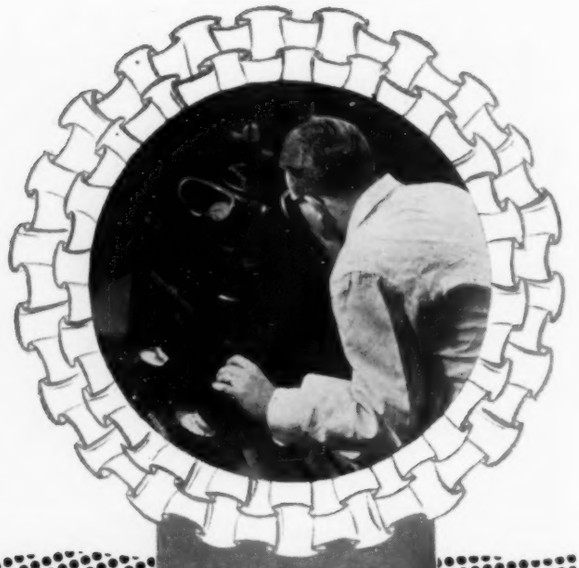

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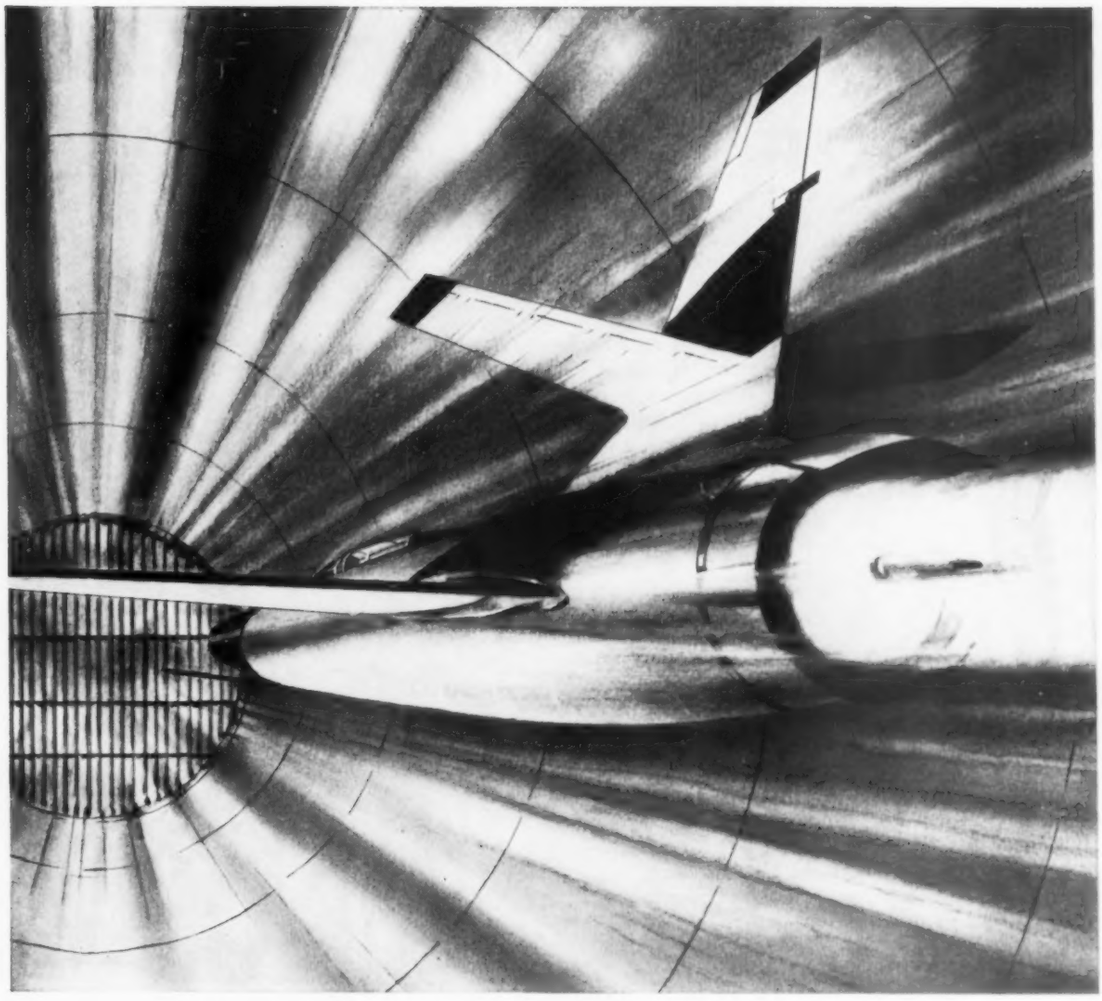

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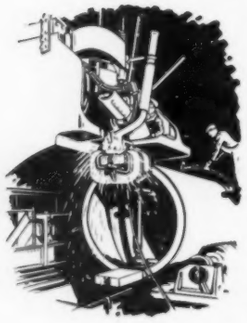

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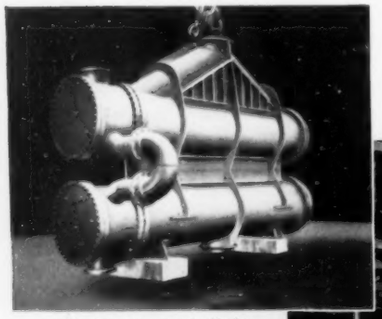
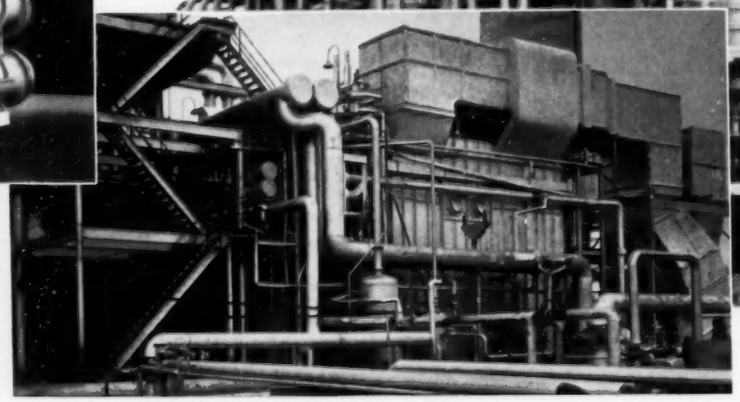


Heat-exchanger built by Babcock for service in an oil refinery.



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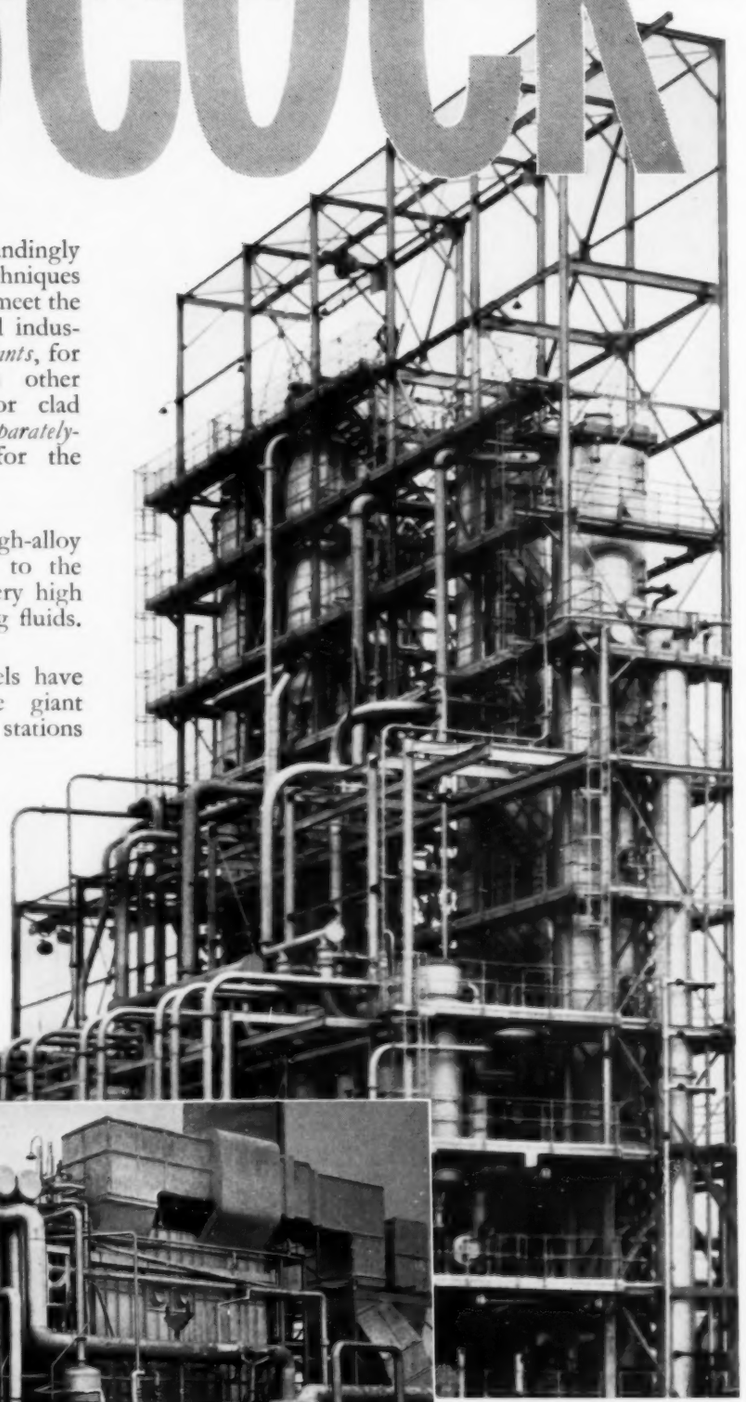

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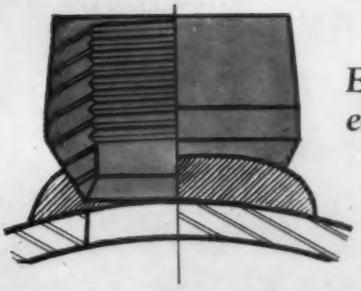

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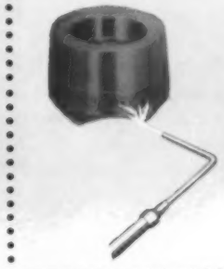

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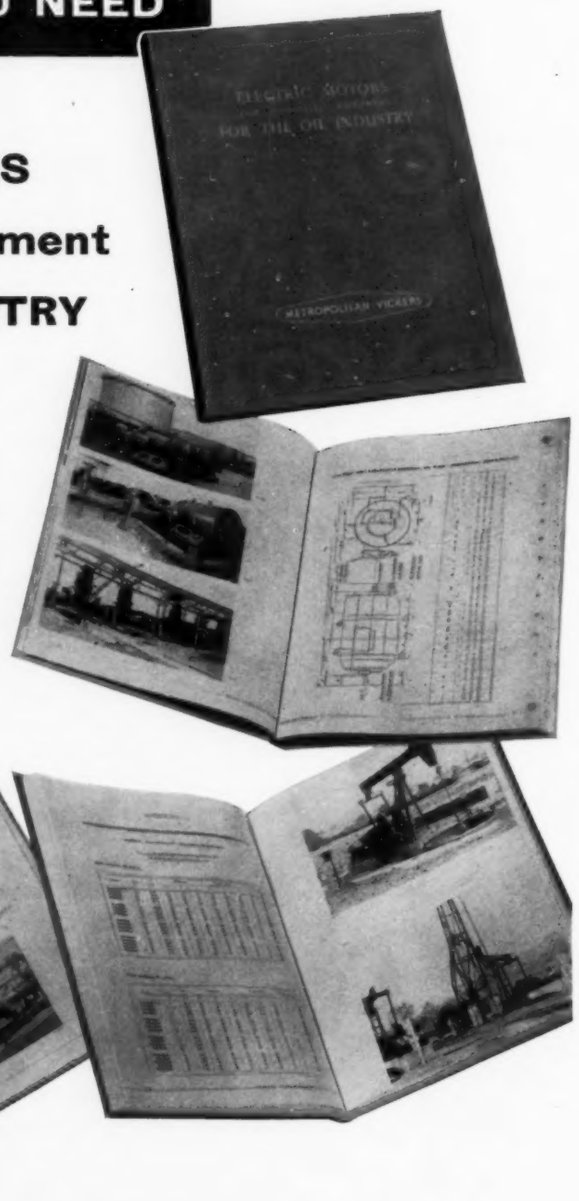

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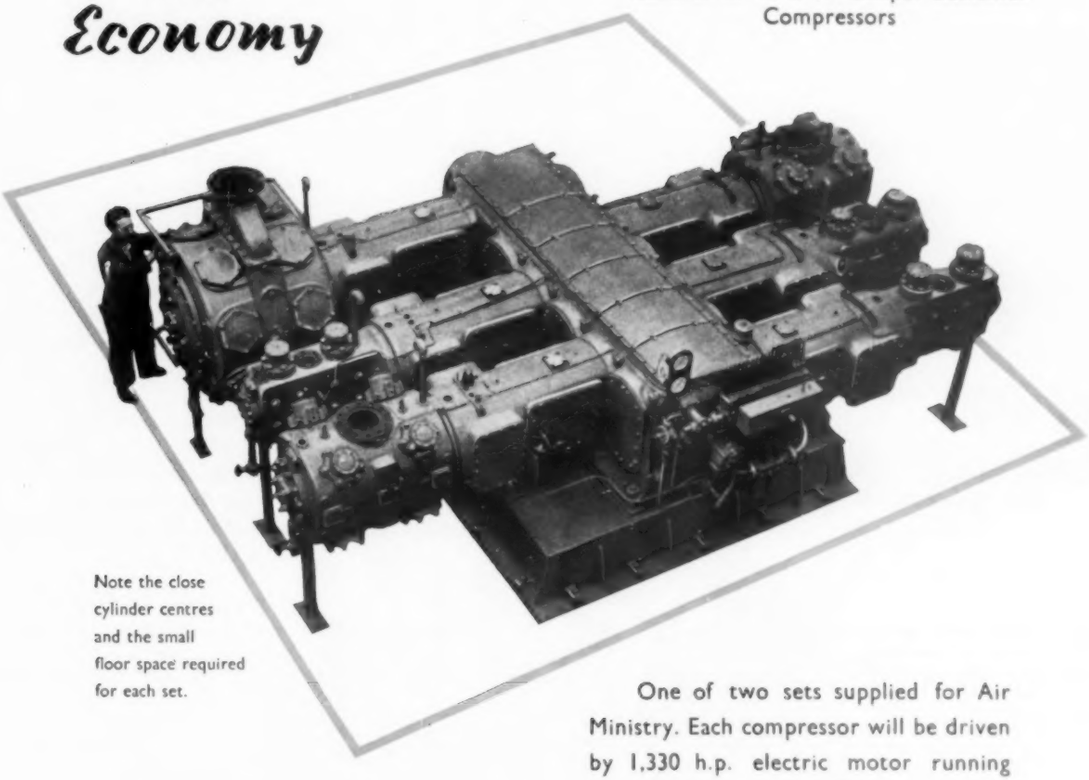

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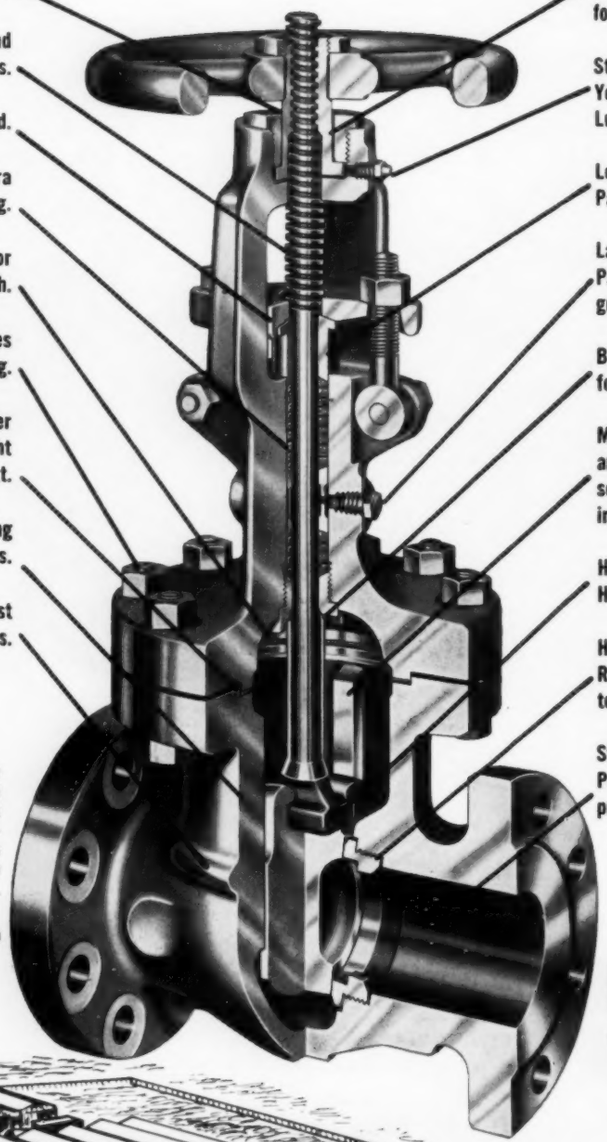

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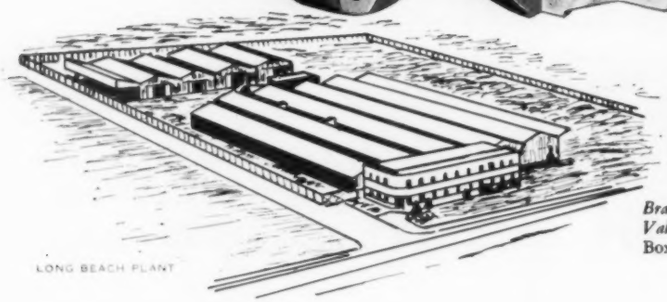

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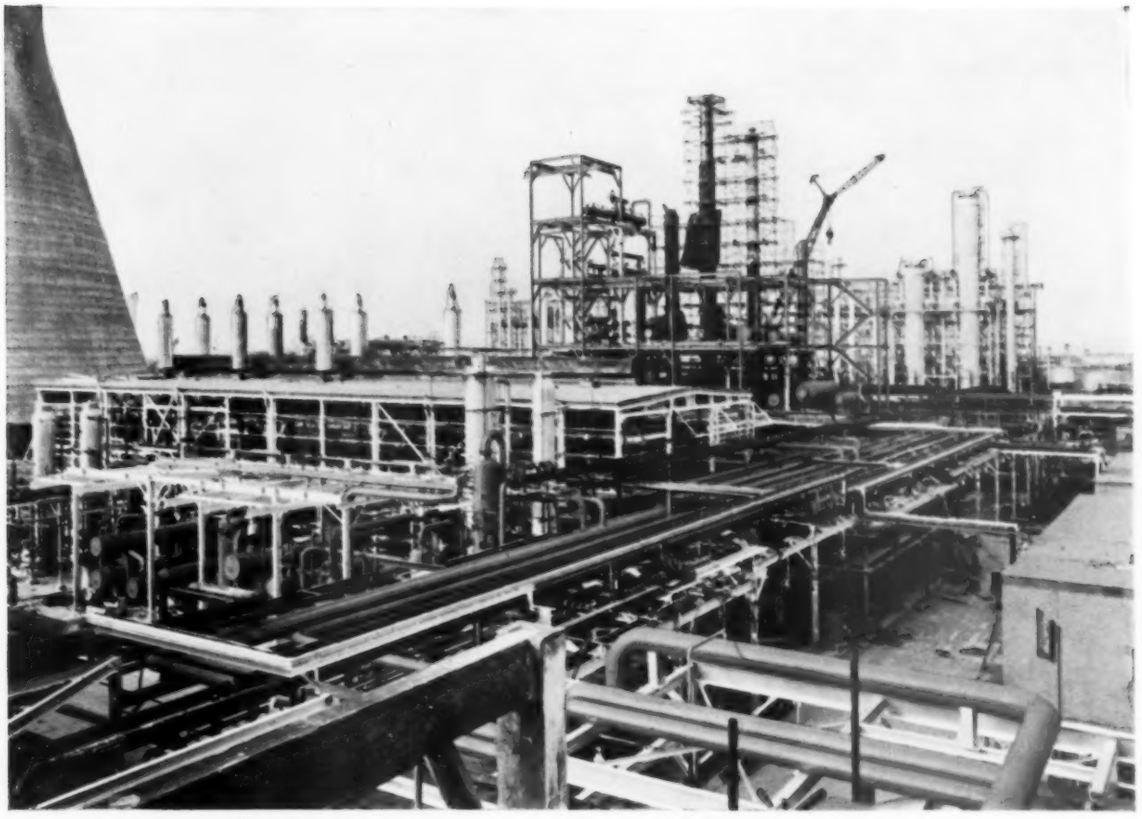

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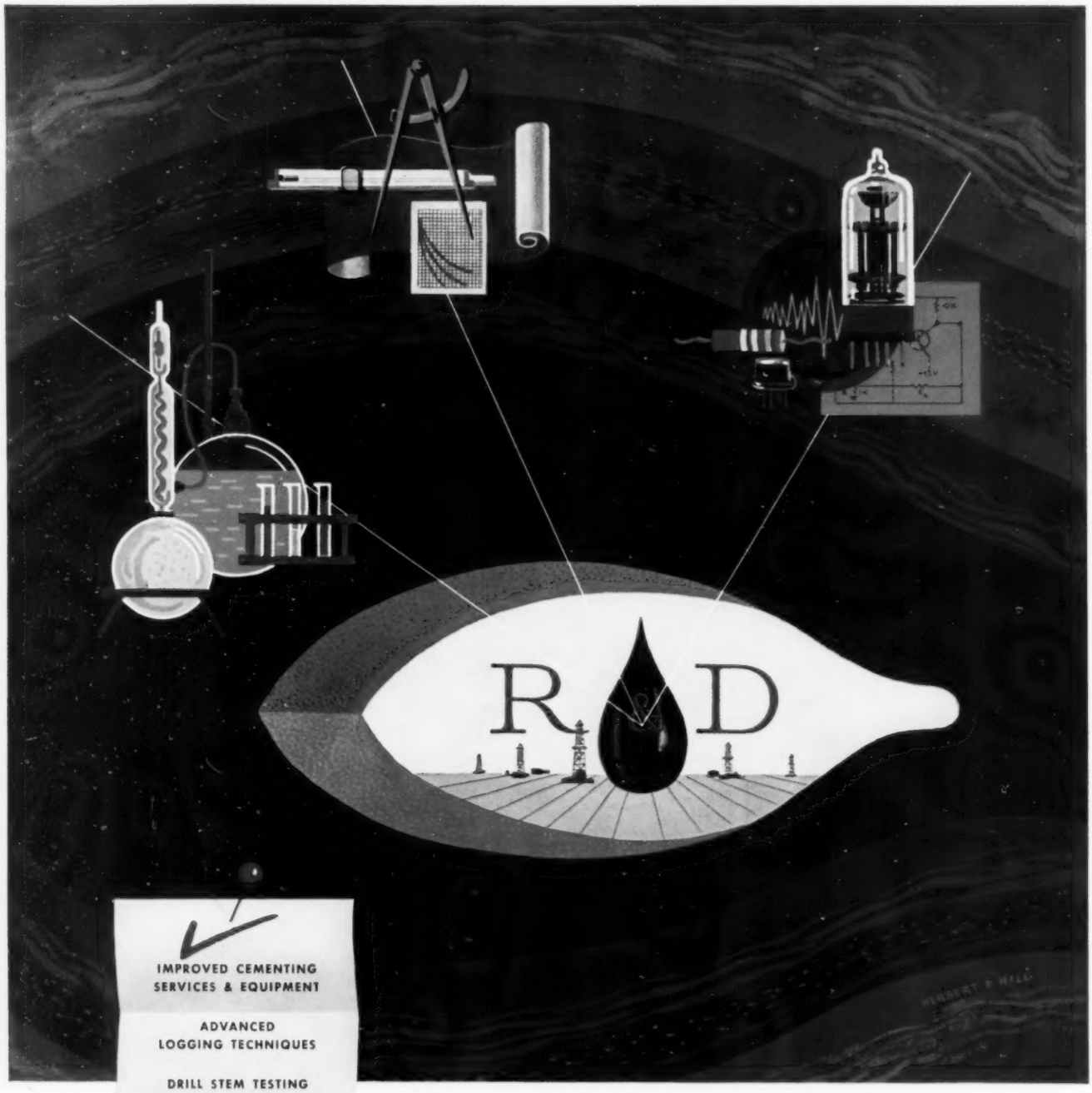

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Performance or Economy

TWO years ago it was predicted by responsible students of the oil and automotive industries that the average compression ratio of 1960 passenger cars in the United States would be about 10:1 and that the "hot" cars of that year would approximate 11:1. On this basis, it was suggested that the five-year period would see an increase of about five numbers in the octane rating of premium fuel from the then current 95+ to 100+. The prediction seemed reasonable in view of the fact that compression ratios and horsepower ratings of cars had been rising at a sharply accelerated rate since 1950. To match the changes in automotive power plants, the refining industry had been advancing its knock ratings about one octane number per year.

The prophets of 1955 now are shown to have been highly conservative. A year ago the June survey of Ethyl Corp. in 57 cities showed an average rating of 97 octane, and this year the average was up to 98.2. Seven cities reported an average premium-fuel rating of 99 or higher. Along the eastern seaboard ratings averaged as high as 99.2 in some cities. Individual samples tested 101.2 and higher. In the month of June the average increase was 0.2 octane, and there were increases of a half octane or more in some cities which had been lagging. In Davenport, Iowa, for example, the May premium average was 96.9, and the June average 98.0. Regular gasoline also went up 0.5 octane in that city.

Superpremium fuels introduced a year ago by Esso Standard Oil Co., Sun Oil Co., and others are fast losing their margin of knock rating over standard premium grades as marketed by those companies which have decided to retain the two-grade system at least for the present. In its June survey, Ethyl picked up 36 superpremium-fuel samples in 18 cities for testing. It was found that the samples ranged in octane number from 100.2 to 102.0. The superfuels thus tested only one to three numbers higher than average competitive premium grades, and were actually lower than some isolated samples.

Following the dedication of its new Delaware refinery late in May, Tidewater Oil Co. announced that the new plant was capable of producing a pool gasoline of 100 ON, and in full page newspaper advertisements the company began offering 100-octane fuel as its premium gasoline under a two-grade system.

Obviously, the octane race is not over. No more is the horsepower race with its attendant rise in compression ratios. Assuming that the present trend continues, it now appears that the "hot" cars of 1960 will require a motor fuel of 110 research octane. The proportion of cars on the road requiring 98 octane and higher will grow to be a respectable percentage of the total fleet.

At the recent midyear meeting of the API Refining Division, a paper was presented by S. P. Blumberg in which he discussed the refinery of 1960 which would be capable of producing a total gasoline pool with a rating of 102.5 research ON with 3 ml of TEL.

Assuming a modern base refinery capable of meeting 1957 competition, Mr. Blumberg added four processing steps to reach the possible 110 octane fuel required in 1960. The four steps included (1) the addition of a desulfurization unit to pretreat catalytic charge stock and an increase in catalytic reforming severity, (2) alkylation, (3) superfractionation to separate C_5 and C_6 isomers and isomerization of normal hydrocarbons in this range, and (4) extraction of aromatics from reformates. A good many plants now have installed two or more of these steps in order to meet 1957 competition, and all are commercially practiced. The Tidewater plant described in this issue employs three of the four steps.

Although the steps are not unique, the cost of all of them combined, as calculated by Mr. Blumberg, is one which may well give pause to management. In terms of capital investment, a 50,000 b/d plant to produce 110 ON gasoline will cost $64 million, or about 39% more than a refinery adequate to meet 1957 market requirements.

Cost of the 1960 product itself is even higher in relation to current figures. It is calculated that a gallon of premium gasoline of 98 octane costs 12.5 cents to produce, while a gallon of 110 octane gasoline will cost 18.52 cents, an increase of approximately 50%.

Faced with such a fuel cost increase in terms of both capital investment and cents per gallon of product, the automotive industry may well ask itself whether the benefits obtained from increased compression ratio should be used up in higher horsepower motors as has taken place in recent years, whether the motorist should be given more miles per gallon, or perhaps a compromise between all-out performance and economy. Indications are that the American motorist is becoming conscious of fuel economy. The one motor-car manufacturer who stresses economy has achieved a 31% increase in sales this year. European economy cars are selling well. It is time for other car manufacturers to feel the buyer's pulse.

The oil refiner obviously must sell his premium and regular-grade motor fuels at higher prices compared with crude markets in view of the mounting cost of octanes. Octane-rating increases can, and will, continue; but it is only fair that the refiner be reimbursed for his extra costs.

◄ *Cities Service Company refinery at Lake Charles, La., as seen through the Spanish moss on the trees bordering the Calcasieu river. Photo by Fritz Henle for Cities Service.*

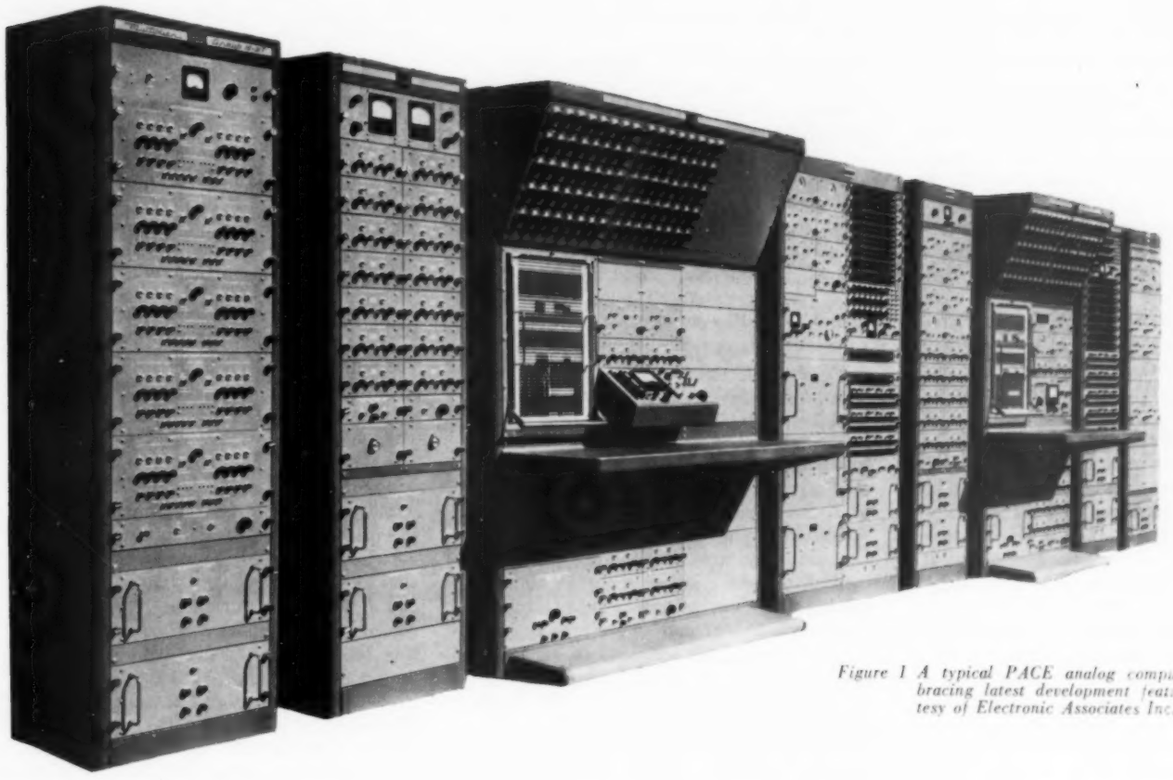


Figure 1 A typical PACE analog computing system, embracing latest development features (photo courtesy of Electronic Associates Inc.)

THE ANALOG COMPUTER ... AN ENGINEERING TOOL

by Charles W. Worley

The analog computer is an engineering rather than an accounting tool. By simulating scale models, the analog permits engineers to solve problems of great complexity which would demand too many man-hours for normal engineering practice. As a tool, it requires skilled technicians to yield satisfactory results.

TODAY'S highly competitive industrial market coupled with the increased costs of material and labor have placed premiums on the efficient design of petroleum processes and products. With the complexity of modern processing equipment this has placed heavy burdens on the engineering departments of petroleum companies. This increased emphasis on technical efficiency coupled with the shortage of technical manpower has led to the development of new engineering techniques. One approach which has proven to be economically attractive is based on the use of high speed computing machinery.

This approach utilizes the computer as a tool for the rapid calculation of the many mathematical expressions encountered in engineering work. Modern computers make these calculations accurately and with unbelievable speed. However, despite their utility they should not be regarded as a panacea for a company's problems. Popular literature has created the image of giant machines with the intelligence of hundreds of men. This is, of course, a false impression since they can be no more intelligent than their designers and users.

Computers are highly capable tools which effectively expand the utility of the engi-

neer. Yet they cannot think for him nor will they automatically solve his problems. In fact, considerable effort must be expanded before solutions to problems are obtained. Because of this, the use of a computer in engineering work generally does not replace any men, but rather increases the amount of effective work that can be done by the same staff. Another important result is that problems and methods are set up for computer solution that would never be considered without the machines. Still another advantage and one that is often overlooked is that the techniques associated with the use of a computer allows problems to be classified which in itself encourages a broader investigation of possible solutions to problems. This cannot help but result in improved engineering effort.

Computers come in all sizes, all speeds, all prices. They can, however, generally be divided into two major categories called *digital* and *analog*. The one deals in numbers only, the other in continuous physical variables. The first computes by repeatedly refining an approximation, and its accuracy is potentially unlimited; in the second type some sort of physical model is set in operation to generate a solution which is valid by virtue of mathematical similarity to the problem being solved. This latter type, the analog computer, is limited in accuracy by the physical elements of the model.

The digital computer by virtue of its ability to handle numbers to a high degree of accuracy is essentially an accounting tool while the analog computer because of its ability to solve continuous physical variables may be regarded as an engineering tool. This does not mean to imply that each type of computer cannot be used in all fields of computation. There are a considerable number of problems which can be solved by both types of computers. However, one type may be more efficient than the other for a particular problem. It is sometimes constructive to employ more than one type of computer on any given problem, since each type may be more effective for certain phases. Thus analog and digital methods may complement one another when applied in sequence, the first pointing the way to an answer and the second leading to any desired precision of the final results. Most certainly, a completely equipped computation facility includes both types of computer.

Analog computers themselves may be categorized into several different types. One important type, not usually called "computers" is represented by true *scale models*. In this a structure or phenomenon is reproduced by changing its physical dimensions without discarding the general physical form. To this type belong such models as the experimental airplane in the wind tunnel, the miniature dam and lake on a table top or even the pilot plant for a chemical unit operation. Somewhat less direct models are those in which the medium is altered; for example, the electrolytic tank used in the study of hydromechanical field problems. Still less direct, but models nevertheless, are the semimathematical types normally identified as analog computers. The physical elements of such computers make available a set of operations, which may be chosen either because they are mathematically fundamental, or because they recur as dynamic relations in the structures being studied.

Indirect analog computers generally carry out or assist in the solutions of equations, algebraic and differential, linear and nonlinear. An extremely familiar and simple example is the slide rule, which is entirely algebraic. At the other extreme is the differential analyzer, which may occupy a roomful in itself, and which can solve some formidable differential equations. This general class of computer is represented in many physical media, even including pneumatic and hydraulic; the predominant realms, however, are the mechanical and electrical. The differential analyzer based on a mechanical disk-type integrator mechanism belongs to the mechanical group. This device is far from being outmoded, but as a practical matter it cannot be operated at a conveniently high speed for certain applications.

The electronic differential analyzer is the most common type of indirect analog computer in use today. The most common form of the electronic differential analyzer is the general purpose analog computer which has been designed to solve many types of engineering problems as opposed to a special purpose analog Computer which is designed to solve a specific problem. A medium size general purpose analog computer installation is shown in Figure 1.

The operation and application of analog computers is perhaps the least understood of the computers in use today. This is primarily due to its relative infancy and to the fact that it is almost exclusively an engineering tool. This lack of understanding is unfortunate since it hinders a true appreciation of where the analog computer can be used in an industrial organization. With this in mind this article will attempt to explain the operation and use of analog computers.

What is an analog computer? An analog computer represents the variables of a given problem by corresponding physical quantities, such as continuously varying voltages or shaft rotations. These machine variables are made to obey mathematical relations analogous to those of the original problem. The desired relations are established by a set of computing elements capable of enforcing suitable physical relationships. The conveniently measurable machine variables will, then, vary so that records of their values or behavior constitute solutions of the given problem. Thus the operation of the physical system being studied in the problem has been *simulated* on the analog computer.

Each problem will require certain relations between problem variables to be set up in the computer. Consider first some examples of relations between two variables:

$$X_o = X_1 + 15X_1^3$$
$$X_o = A\,X_1$$

In each case, X_o and X_1 are voltages; and the voltage X_o is a function of the voltage X_1. If X_1 changes, X_o must also change, in accordance with the given relation.

Figure 2a shows schematically how such relations are represented in an analog computer. The voltage X_1 will appear as an input voltage of a block of computing elements which produces X_o as an output voltage. This output voltage will be the desired function of the input voltage X_1 if the correct combination of computing elements has been used. Note that, in general, the relation produced by the block in Figure 2a is "unilateral"; whereas changes in the input voltage X_1 will produce the correct changes in X_o the converse is not true un-

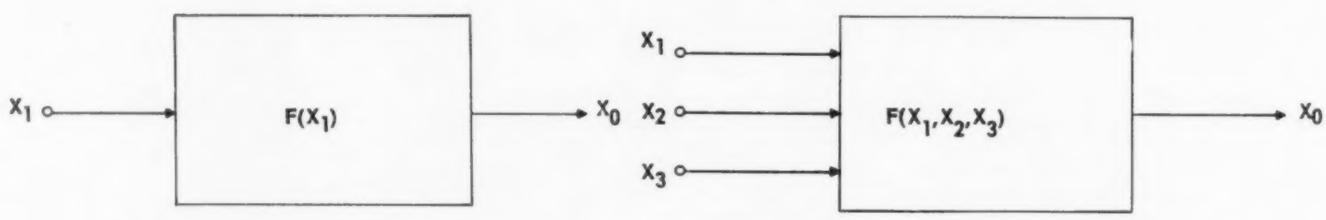


Figure 2a Generalized block diagram for the generation of a function of a single variable with an analog computer.

Figure 2b Generalized block diagram for the generation of a function of several variables with an analog computer.

less additional connection and computing elements are used.

Quite often a voltage X_o will appear as a function of several other machine variables X_1, X_2, X_3, etc.

$$X_o = X_1 + 19\,X_2 + 27\,X_3$$
$$X_o = X_1\,X_2^2$$

The block of computing elements producing X_o as its output voltage will have more than one input voltage. The effects of the different input voltages X_1, X_2, etc. are "mixed" to produce the correct functional relation as shown in Figure 2b.

Other problems will require the solution of equations containing a variable occurring on both sides of the equation such as

$$X_1 = X_2^2 + 2\,X_1^3 - X_1^2$$

This solution is obtained by feeding the output X_1 back as an input as shown in Figure 2c.

Still other problems require the solution of simultaneous equations of the type

$$X_1 = X_2 + X_1^2$$
$$X_2 = X_1 + 9\,X_2$$

The generalized block diagram for solving these simultaneous relationships is shown in Figure 2d.

In many problems, it is desired to observe the variations of the variables as functions of time t, which plays the part of the independent variable in the computer. For example, the relations

$$X_1 = X_2$$
$$X_2 = \text{Sin } \omega t$$

describes the variations of two variables, X_1 and X_2, with the time t. Physical time t here serves as an input to certain computing elements which produce voltages as functions of time. These elements usually take the form of electrical circuit containing charging or discharging capacitors. The computer voltages can thus be made to vary with time in the prescribed manner

It is easily seen that a majority of problems in engineering require a description of changes of quantities involved in physical processes. The differential calculus is the branch of mathematics concerned with the description of such changes. Thus, the study of physical processes requires the solution of differential equations, a task which becomes formidable for complex processes yet is handled easily with the analog computer.

What an analog computer will do. Compared with other computing devices, d-c analog computers are often quite simple. The reason for this is in the relative ease with which the fundamental mathematical operations can be performed by utilizing basic laws of current flow.

It will, in general, be desirable to make a computing machine easy to operate and maintain for a wide variety of problems. Accordingly, it is customary to obtain more complicated mathematical operations through combinations of a limited number of simple operations, performed by basic computing elements. It has been proved explicitly that a very wide range of problems can be solved conveniently by the use of the following mathematical operations.

1. Addition or subtraction.
2. Integration.
3. Multiplication by a constant less than unity.
4. Multiplication by a variable.
5. Division.
6. Generation of Arbitrary functions.

Unlike digital computers, analog computers, employ distinct computing elements for each mathematical operation required to solve a given problem (parallel operation). Parallel operation is an essential reason for the very high computing speeds possible with the d-c analog computers: most problems, regardless of complication, are solved within minutes by general purpose analog computers and within fractions of a second by repetitive machines. On the other hand, parallel operation imposes practical limits on the complexity of problems which can be solved on analog computers. The average problem solved today employs from 30 to 100 operational amplifiers while problems requiring 100 to 500 amplifiers are not uncommon. Also, the cost of analog computers with component accuracies of better than 0.01% rises sharply for even small improvements in accuracy. For computations requiring very high accuracy, the use of digital computers is thus indicated.

Elements of an analog computer. The principle computing element of the general purpose analog computer is the operational amplifier. Essentially an operational amplifier is a high quality, high gain (up to 600 million) d-c amplifier. It is used in the computer to perform the mathematical operations of arithmetic and calculus on the voltages applied to its input. The desired mathematical operations are obtained by using appropriate electrical components as input and feedback networks for the amplifier.

By judiciously combining basic computing elements one can design complete d-c analog computers for a wide range of applications. A modern d-c analog computer will, in general, comprise the following components in one form or another:

1. *Linear computing elements* (operational amplifiers and associated networks). These will perform the operations of am-

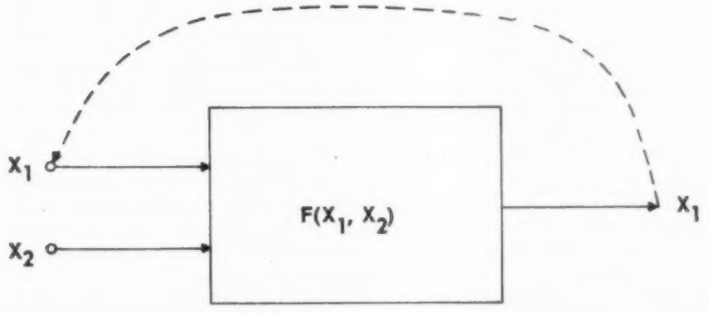


Figure 2c Generalized block diagram for the generation of an implicit function of an analog computer.

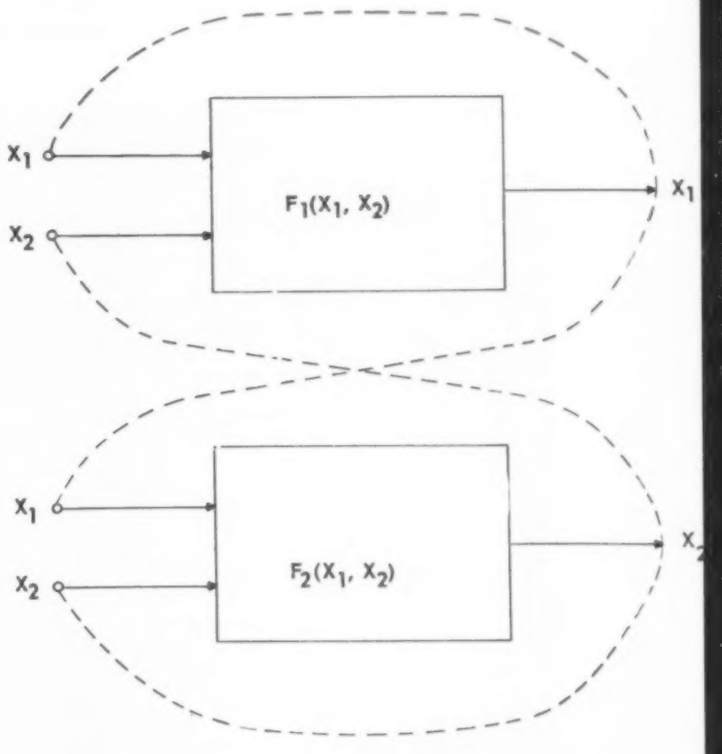


Figure 2d Generalized block diagram for the solution of simultaneous equations with an analog computer.

plification, phase inversion, differentiation, and integration, as necessary. The cost and complication of these and other computing elements will depend on the required accuracy.

2. *Potentiometers or attenuators* to set constant coefficients.

3. *"Non-linear" electronic or electro-mechanical computing elements* for performing operations such as multiplication, division, function generation, and limiting. Such devices are needed if the problems to be solved call for non-linear operations.

4. Permanent wiring or flexible means for *interconnecting* those computing elements as needed for the problems in question. Patchcards and jacks used for this purpose are usually plugged into a removable *problem board*, which in-turn is plugged into the machine proper.

5. *Control circuits* for starting the computation with the correct initial-conditions and for stopping the machine after the computation is completed.

6. Means for *recording* or *measuring* the d-c voltages in the machine. Recording millimeters or servo-plotting boards are commonly used to furnish a permanent record of voltages against time or other voltages.

7. Regulated power supplies which furnish the voltages needed for the operation of the electronic components.

These basic computing elements and associated equipment are combined into a completely integrated system to form the general purpose analog computer.

To facilitate the actual operation of the computer a computer diagram is usually drawn which shows the interconnection of the various computer components used in the solution of a specific problem. For complex problems this diagram would become quite complicated if all the electrical connections were included. For simplicity a group of symbols for the various mathematical functions performed by the computer devices have been developed. The most common symbols used are shown in Figure 3.

Steps in the solution of a problem. The variables of the problem are represented in the analog computer by corresponding voltages. In general, these machine variables are simply proportional to the corresponding original problem variables. The proportionality factors are arrived at by the process of "scaling" the problem to the machine. The values of the scale factors, both amplitude and time, depend upon the problem, the type of machine used, and the method of recording the results of the computation. The given relations between the original variables are thus expressed by an analogous set of machine equations which, in-turn, are solved by the computer.

The step-by-step procedures used in solving problems on the analog computer are as follows:

1. Statement of the problem.
2. Obtain problem equations.
3. Select scale factors.
4. Derive computer equations.
5. Draw computer diagram.
6. Calculate coefficient potentiometer settings.
7. Patch problem board.
8. Set coefficient potentiometers and initial values.
9. Run computer check solution.
10. Conduct computer program.

Analog computer results are normally presented graphically as a continuous plot of the variable quantities. Figure 4 shows actual results of a computation as it is being recorded. For many problems this method of presentation is most convenient for engineering use. The graphical presentation of results has another important aspect. It is relatively easy for the engineer, as he operates the analog computer, to visualize the results as the actual response of the physical system under investigation. In fact, thinking of the analog computer as a mathematical device is discouraged as much as possible. Its usefulness will be greatly enhanced if the engineer views it as a tool to help him think in terms of the physical system.

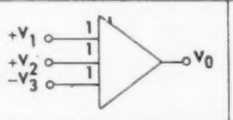
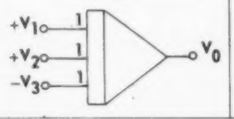
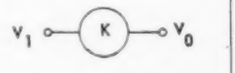
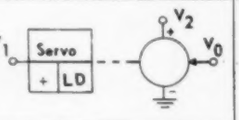
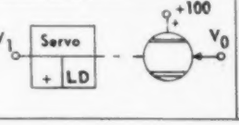
NAME	SYMBOL	FUNCTION	DESCRIPTION
A. Summer		$V_0 = -(V_1 + V_2 - V_3)$	Amplifier Multiple input
B. Integrator		$V_0 = -\int(V_1 + V_2 - V_3)dt$	Amplifier Multiple input
C. Attenuator		$V_0 = K V_1$ $(0 < K < 1)$	Manually set potentiometer
D. Multiplier		$V_0 = \frac{V_1 V_2}{100}$	Servo driven potentiometer
E. Function Generator		$V_0 = f(V_1)$	Servo driven, multi-tapped potentiometer

Figure 3. Symbols for basic computing elements in an analog computer.

Use of analog computers. The general purpose analog computer has proven itself a very powerful tool in the solution of differential equations. Perhaps the most extensive and fruitful applications have been in the field of automatic control engineering. Analog computing elements lend themselves naturally to the representation of feedback loops analogous to those used in control systems, and the analog nature of the computer input and output data permits one to introduce components of actual systems into the feedback loops for partial system tests. Investigations of different components and systems can thus be made under very realistic conditions.

Applications of analog computers to the study of the control of industrial processes are many and varied. However, despite the wide variety in types of processes encountered, there are basic similarities between systems which facilitate their analysis. For instance, due to the similarity in operation of commercially available instruments and controllers their analog representation are basically the same regardless of the type of process being studied. Consequently, the computer circuits for representing control devices can be standardized.

This is not true for process characteristics. Although determining the process equations can become quite difficult for complex processes, experience has shown that a considerable degree of success can be achieved using basic chemical and physical laws. For instance, the hold-up of material in a tank or reactor can be determined by writing a material balance equation. This equation is a simple statement of the physical fact that the amount of material in the volume is equal to the difference between the amount of material flowing into the volume and the amount of material flowing out of the volume, all evaluated over a finite time period. The same type of reasoning can also be applied to the flow of heat. Usually, a combination of basic laws and pertinent test data result in an acceptable process representation.

The following examples are presented to illustrate the type of control problems of interest to the petroleum industry which have been successfully solved with the use of the analog computer.

Batch process control system study: The particular process analyzed occurs in the manufacture of photographic emulsions but

the techniques used in the analysis are equally applicable to processes more closely related to the petroleum industry. For satisfactory product quality this process required a very close temperature control. The process and several different control systems were represented on the computer. Changes were made in the system constants until the desired temperature control was obtained. The study resulted in the selection of a control system using standard instrumentation which gave the desired temperature control. Subsequent operation of the process has shown close argument with the results of the computer study and has resulted in improved product quality.

Hydrogenation re-cycle process redesign: The objective of this study was to analyze the performances of an existing chemical reactor whose operation had proven to be unsatisfactory in that the product produced was constantly below specifications. The process equations were obtained by dividing the reactor into geometric sections. Heat balance and material balance equations were written for each section yielding a group of simultaneous equations whose solutions represented the performance of the reactor. Non-linearities due to the physical size of the reactor and the finite rate of flow of the recycle fluid through a fixed length of pipe were included. The operation of the computer "model" was then checked with the operation of the actual process. Good correlation was obtained with a few adjustments in system constants. The next step in the study was to apply different control systems to the model and evaluate their performance for the various disturbances present in the process. This approach would have been virtually impossible on the actual process but was simple to follow on the analog computer. The reactor is now in operation with a control system designed by the computer study and consistently produces a high quality product.

Condensor control system design: This problem was concerned with the analysis of a medium sized heat exchanger used in the recovery of a vapor. The purpose of the analysis was to design an automatic control system for the control of condensate temperature. Equations were developed to represent the heat transfer characteristics of the heat exchanger. Circuits equivalent to these equations were patched into the computer to represent the operation of the heat exchanger. Several control schemes were tried for controlling the temperature of the condensate. Study suggested modifications to the control system which resulted in better temperature control.

The use of the analog computer is not restricted to automatic control studies. Because of its ability to quickly solve simultaneous equations, its use has been extended into the design of processing equipment and to the study of the physical phenomenon occurring in a particular process. Two examples will be cited to illustrate these applications.

Distillation column design: Plate-by-plate design calculations for a non-ideal, multi-component distillation column were made to determine the number of plates required to meet process specifications. The calculations were divided into two parts by working first *up* from the reboiler then *down* from the top plate; in each case the objective was to match the feed plate composition. The calculations were repeated for various top and bottom compositions, heat inputs, and top solvent rates until an acceptable feed plate match was obtained. The calculations made for each plate were steady-state and were based upon standard expressions normally used in hand calculations. Non-linearities associated with the heat and materials balance were included in the calculation. The transfer from one plate to the next was made semi-automatic in that the results of a previous plate calculation was stored for use in the following plate calculation. The results were plotted as a function of column plates.

Distillation calculations made with the analog computer were found to be more accurate than the previous hand calculations and considerably faster. This study also showed an economy in programming of approximately 10 to 1 for the analog computer over the digital computer. Of course, the digital computer gave more accurate computations. However, the results of this study has shown that the analog computer can be highly valuable for multi-component distillation design calculations.

Petroleum reaction analysis: This study was made to determine the optimum temperature distribution in a four-stage reaction. The reaction equations for a five component mixture were solved on the computer. A heat balance based on the material produced by the reactions was made to determine the temperature changes due to the reaction. This temperature change then determined the reaction rate of each component in the mixture. Various temperature changes between reactor stages were investigated to determine the optimum temperature distribution for a desired product quality. Net effect was to reproduce a chemical reaction without constructing an expensive pilot plant.

These examples are but a few of the petroleum and chemical problems successfully solved with the analog computer. Increased emphasis on cost reductions is causing considerable interest in expanding the scope of problems which are adaptable to analog computation. The increased availability of analog computer installations to industrial organizations are each day producing new applications.

The environment in which the petroleum and chemical industry operates is continually changing. New manufacturing processes can only be developed from an intensive research effort. Available raw materials, specifications for products and the relative demand for them, increased prices and costs all point to the development of new processes. General purpose analog computers provide one of the most powerful tools of modern science for the design of these new processes. The uses to which they can be put is limited only by the imagination and knowledge of the engineer and executive. END

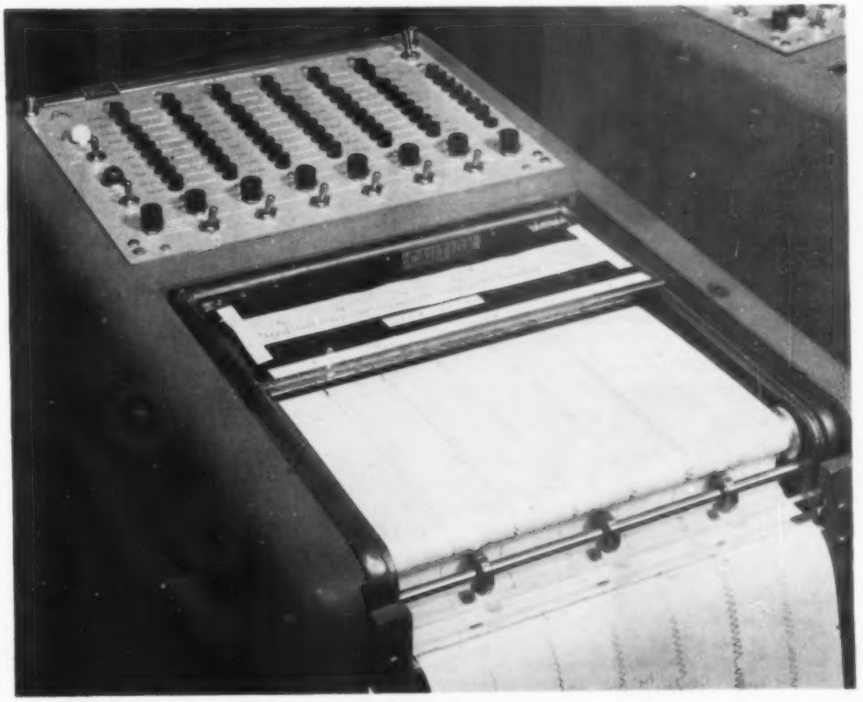
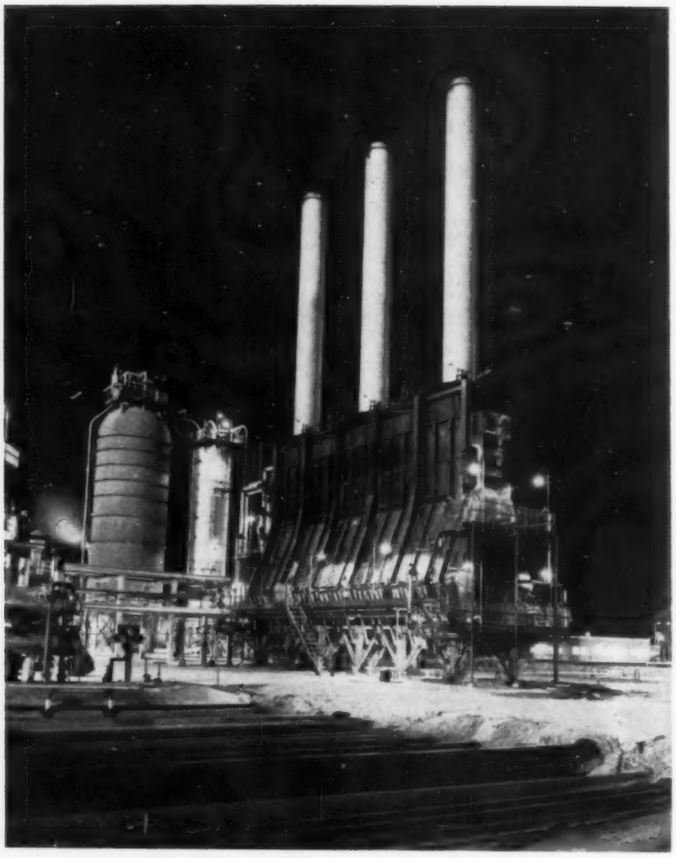


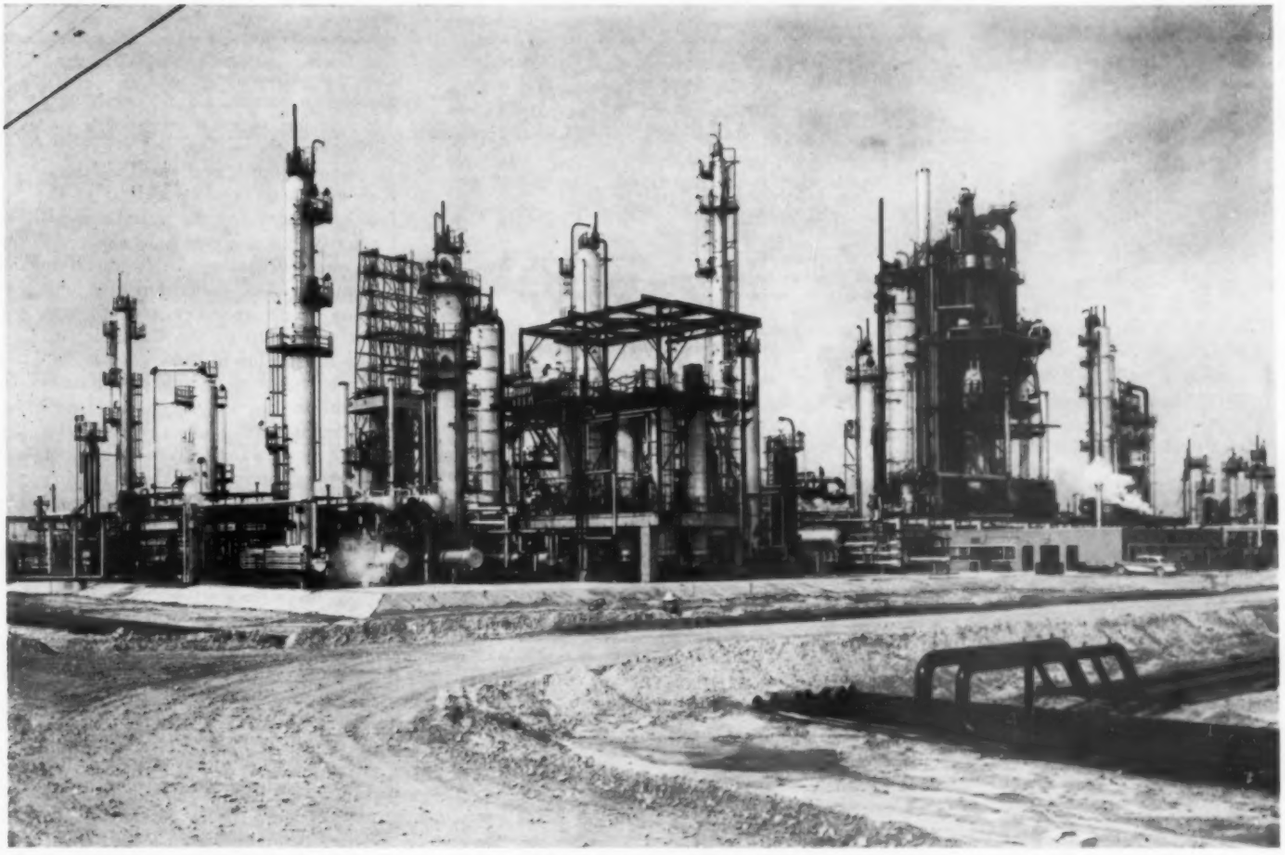
Figure 4 Recorded results of an analog-computer computation.



Combination-unit crude and vacuum furnace, located at end of the plot, at Yorktown refinery.

Process integration and flexibility feature Amoco's Yorktown plant

by Douglas A. Mirk



Southeast corner of combination unit, showing cat-poly section in foreground: Cat cracker and fractionator, and gas-recovery sections, are in right background (M. W. Kellogg photo).

Annual shutdowns at Amoco's new Yorktown refinery may be scheduled to take advantage of seasonal fluctuations in demand, and emergency shutdowns of individual units can take place with minimum disturbance to the remainder of the refinery.

On an 800-acre site less than three miles from the scene of the final battle of the American Revolution, Virginia's first oil refinery was completed recently by The American Oil Co. The plant is one of the two completely new refineries built on the eastern seaboard this year.

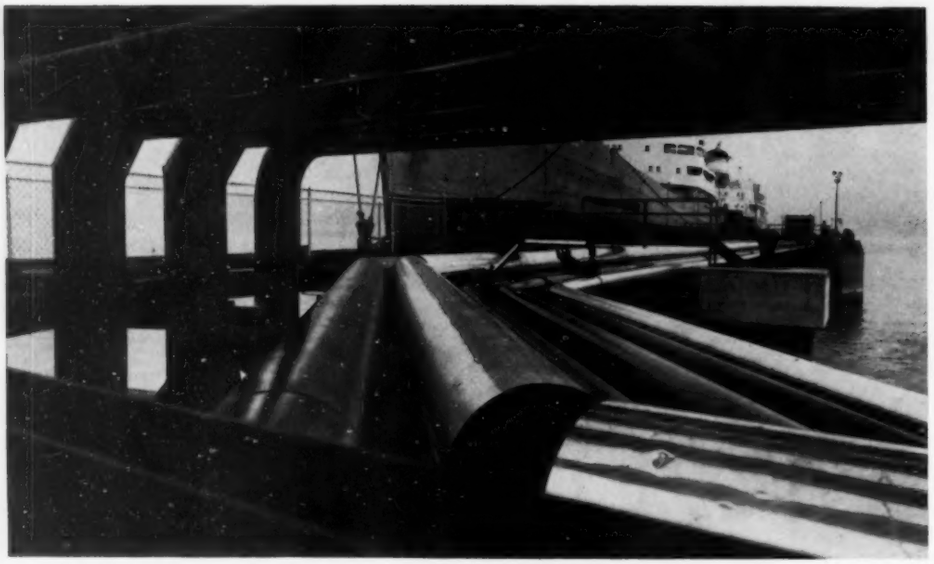
Many of the strategic values which caused General Cornwallis to select Yorktown as a field of battle are those which caused Amoco to select it as an industrial site. It is (as Cornwallis had noted) accessible from the sea. This is essential for receiving crude oil direct by tanker and for shipping products to ports along the East Coast. It is also within easy reach of a railroad (the Chesapeake & Ohio)—permitting the distribution of products inland by rail car direct from the refinery, as well as rail shipment to the refinery of catalyst and other materials essential to its operation. One of the finest highway systems in America facilitates the distribution of products by truck to the surrounding local market. The terrain of the site is flat and out of reach of the Chesapeake tides. The soil is, for the most part, sufficiently firm to support major refinery structures without requiring spread footings of piling. Fresh water and electric power are available from the utility companies serving this area—and, of course, the York River provides an inexhaustible source of cooling water.

The selection of this site was further enhanced by a somewhat unique and mutually attractive arrangement with the local power company. The growing demand for electrical energy in the region served by the Virginia Electric Power Co. would soon require that additional generating capacity be added to the power system. Amoco agreed to sell one end of its property to VEPCO as a site for a new generating station, and thus gained a nearby dependable source of electric power. In addition, arrangements were made whereby the generating station and the refinery would obtain their cooling water from a common forebay at the end of a channel from the York River—thus avoiding a duplication of those facilities.

Process Facilities: Amoco's Yorktown refinery is designed at present to process 35,000 b/sd of crude oil. The finished products include premium and housebrand gasoline, kerosine, fuel oil (No. 2 and bunker "C"), LPG, and coke. Also, since surplus fuel gas is metered and sent to VEPCO's generating station it too may be considered a product.

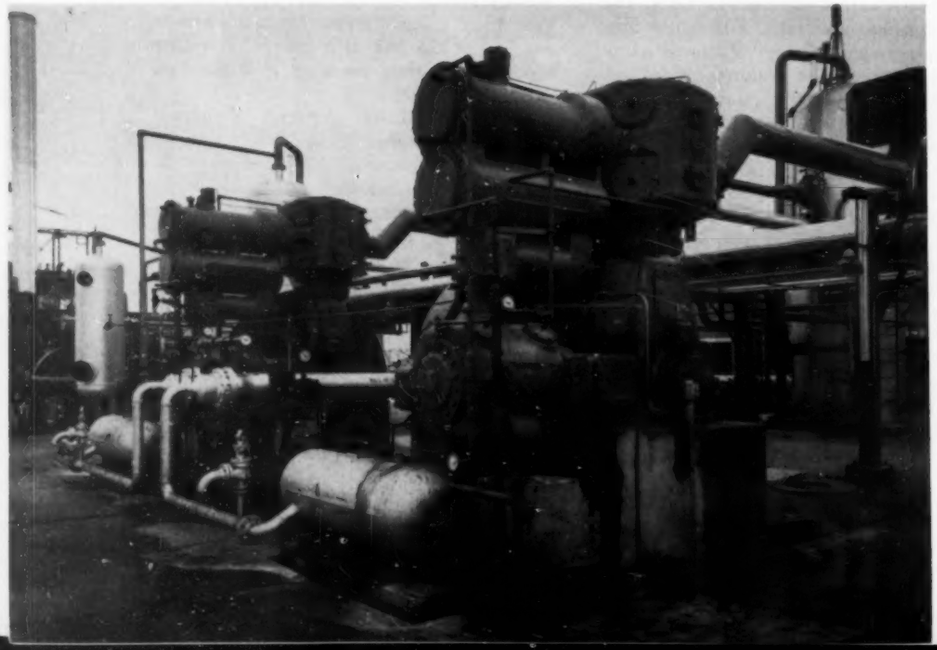
The existing processing facilities consist of a combination unit, a hydrodesulfurization unit, a reformer, and a delayed coker. The combination unit, which was designed and built by The M. W. Kellogg Co., in-

A settling basin at the Yorktown refinery, measuring 400 ft by 500 ft, impounds and clarifies runoff and process waters through a labyrinth formed by three earthen dikes. An oxidation pond covering nearly five acres (shown in part at right) restores natural oxygen content of these waters before they leave the refinery (M. W. Kellogg photo).



Crude and product transfer lines, looking toward marine facilities for tankers, at Amoco's Yorktown refinery (photo, courtesy M. W. Kellogg Co.).

Two plant air compressors, showing outdoor-type construction used in the power station at Amoco's Yorktown refinery (M. W. Kellogg photo).



cludes an atmospheric-and-vacuum crude-distillation section, a fluid catalytic cracking and gas-recovery section, a catalytic polymerization section, and a gasoline and kerosine treating section. The cracker is Kellogg's Orthoflow (model "B"). The reformer is of Standard of Indiana's Ultraformer design, and was built along with the hydrodesulfurization unit by the Ralph M. Parsons Co. The delayed coking unit, including a gas-recovery section, was designed and built by the Lummus Co.

The integration of these process facilities has been made as complete as possible. In addition to the regular product tankage, intermediate tankage is available for the unfinished products from these various units—thus permitting their independent operation for limited periods. However, this intermediate storage may be bypassed during normal operation by interconnecting lines between the various units. During this method of operation, the intermediate product streams are uncooled—thereby conserving the maximum process heat and minimizing the total process-heat input. Even within the combination unit, the various sections may be shut down and isolated while others continue to operate.

The net result of these integration and flexibility features is improved operating efficiency The annual shutdowns of the various process units for routine maintenance and inspection may take full advantage of any seasonal fluctuation in the demand for the products from a particular unit. Disturbances to the refinery operation due to an upset or emergency shutdown of an individual unit are minimized. Also, interruptions to accommodate the tying-in of future process units will be unnecessary.

Refinery Layout: The general arrangement of the refinery embodies the principle of unidirectional flow; while basically simple, this layout, nevertheless, combines low initial investment with optimum provision for future expansion without sacrificing either safety or appearance.

The oil flow through the refinery is basically west to east. All charge stocks are stored at the western end of the refinery. The process area is located just to the east of this storage, and extends to the north and south boundaries of the refinery proper—thereby separating the charge storage from the product storage and its transfer facilities which lie to the east of the process units. East of the product storage are the product-loading facilities consisting of a marine terminal, a tank-car loading station for rail shipment, and a truck-loading rack. Crude oil is brought in by tanker and pumped by the ship through a 24-in. line to the crude storage tanks located in the southwest corner of the refinery two-and-a-half miles from the marine terminal. This long run of a single line not only made possible a net saving in piping costs by shortening the six product lines averaging nearly 16 in. in diameter to the marine terminal, but it also permitted savings in both the initial and oper-

ating costs of the product-loading pumps.

The charge-stock storage and the product storage required for the present plant capacity are located along the west and east boundaries of the process area, respectively. When future process units are added north and south of the present units —which are centrally located in the process area—the feed and product-storage facilities can be expanded to the west and to the east opposite the new units as necessary to accommodate them. This arrangement thus kept the initial capital investment low by concentrating the feed and product tankage near the existing process units without imposing any penalty on the costs of future plant expansion.

The location of the coking unit, while deviating from the general plan outlined above, actually is in accord with the basic arrangement philosophy of maintaining unidirectional flow from feed through process to product storage and loading. In the case of the coker, its only finished product is coke which is destined for the VEPCO generating station situated along the western edge of the refinery. The coke is hauled in a large Euclid earthmover over a heavy-duty roadway from the coke pile at the coker to VEPCO's stockpile a quarter of a mile away. By locating the coker to the west of the process area, this hauling distance was minimized. The other principal products from the coker are gas oil and heavy gasoline, which make up part of the feed stock to the catalytic cracking and hydrodesulfurization units, respectively. The rundown lines for these two products go directly to the above process units as well as to their feed storage located on either side of the coker. Thus, the optimum lengths for coker-feed and rundown lines, as well as the coke-hauling distance, are achieved by the coker's location without serious interference to the feed-storage layout or violation of the unidirectional flow principle.

The refinery effluent-treating and oil-recovery facilities are located along the eastern boundary of the refinery. All sewerage and drainage gravitate from west to east into these facilities.

The refinery power station is centrally located in the process area—thereby being as close as possible to the principal users, both present and future, of the utilities produced by or distributed from these facilities. Room has been left for the ultimate expansion of this utility center to the east.

The flare stack is located in an open area just north of the power station and is, therefore, ideally situated for serving not only the existing processing facilities, but also future units. Additional clearance has been provided to leeward of the prevailing winds to assure maximum safety.

The layout of the road and rail systems enables them to serve adequately, and as necessary, all areas without awkward or numerous crossings of major traffic arteries. Nearly 16 miles of roadways exist within the refinery, their surface treatment being crushed stone sealed with road oil. Except around the process area, roads are elevated only 6 in. above grade. Pipe crossings consist of corrugated pipe sleeves through which the lines are run, while the road is gently humped to provide adequate covering. Humping is also used to clear culverts at drainage crossings.

This network of roads affords quick and easy access to all areas and facilities within the refinery. All tankage borders on a road, and is thus readily accessible to mobile fire-fighting equipment. The plant safety, which depends so much upon this road system, is further enhanced by the street lighting. Mercury-vapor fixtures fitted with lenses to give type-2 distribution are mounted on wooden poles, and provide excellent illumination for all roadways including that on the dock.

The refinery railroad enters from the southwest corner, traverses the refinery along its southern edge, and finally ends at the tank-car product-loading rack. Spurs branch off from this main trackage to serve the warehouse and the combination unit. Altogether, including sidings, there is approximately three miles of railroad within the refinery, built to the specifications of the C & O Railroad. Plant security is maintained with minimum personnel, and without delaying the rail traffic, by use of electrically-operated gates remotely-controlled from the main gate house to permit the passage of rail cars in and out of the refinery.

Offsite Facilities: While the rundown of all finished liquid products from the processing facilities to storage is accomplished by pumping or pressuring these streams from the individual process units, any further movement of these products or product components requires the services of an additional pumping facility: the product transfer manifold. Located in very nearly the geographical center of the refinery, just east of the power-station area and south of the main yard bank running east and west, it is through here that all finished liquid products pass from storage when transferred, blended, or distributed to the refinery product-loading stations.

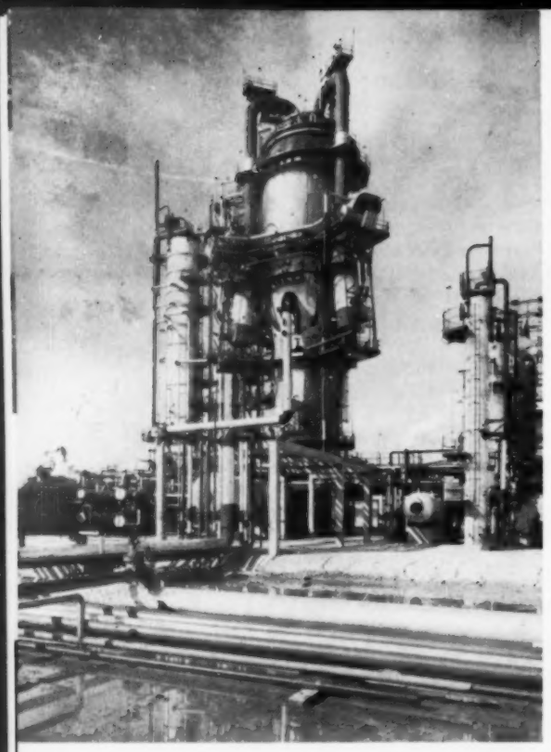
The layout of these facilities has three basic objectives: (1) flexibility with respect to pumping and transfer combinations; (2) provision for future expansion and/or tie-ins; and (3) full utilization of tankage capacity. The first of these objectives was accomplished by forming a rectangular grid, with the pump headers extending east over the piping leads running north and south. Valved interconnections drop down from the pump headers into the leads beneath, in any desired combination. By providing clearance between the leads to permit the continuation of any line in a north-south direction through the manifold area while at the same time allowing sufficient room for extending the yard bank eastward away from the pumps, the second objective, viz., provision for future expansion, was achieved. The third objective, that of utilizing the full capacity of the refinery's product storage was attained by setting the entire manifold, which covers over a third of an acre, in a pit about 3 ft deep.

One of the functions of this manifold is that of distributing the properly blended products from their main storage to the tankage serving the product-loading stations for trucks and tank car. However, since there is no such tankage for the marine terminal, the transfer pumps must in this case act as product pumps by taking suction from storage and discharging directly into the tanker. By far the greatest volume of the products leave the refinery in this manner. The pumps in this ship-loading service have a capacity of 7,000 gal per min, and are driven by motors up to 1,000-hp in size. The investment in these large pumping facilities is easily justified by making possible quick turnarounds for even the largest tankers in this service—the loading operation usually requiring less than 12 hours.

Product blending is, of course, a somewhat more complicated operation than product transfer or loading. While lacking the metering accuracy required for a true in-line blender, nevertheless it is possible for these facilities to combine simultaneously several component streams to produce approximate blends in the final product tankage. A remote-gauging system provides a check on the actual component quantities used—thus permitting an accurate topping-off of the final product blend. In blending, say, housebrand gasoline, four separate component streams can be combined simultaneously. Flow controllers in the discharge headers from each of the component pumps are adjusted as necessary to maintain theoretical flow quantities. The vapor pressure (Reid) of both gasoline streams leaving the manifold on their way to storage is recorded continuously and automatically.

Except for the alignment of the valving, all of the functions performed by these product-transfer and blending facilities are conducted from the control room adjacent to the transfer manifold. Mounted on the control board are remote start-stop buttons for the transfer pumps and the recording flow controllers for the various component streams, as well as the vapor-pressure recorders for the two gasoline streams. Also located in this control room is the indicator panel for the remote rank-gauging system which provides the operator with an indication of the lquid level in any of the feed or product tankage. By having all data associated with the blending and transfer operations available at the pump controls, the opportunity for operator and communication errors is considerably reduced —thus minimizing the wasteful formation of off-specification products and enhancing the plant safety.

The waters of the Chesapeake are famed, of course, for their commercial fishing. The American Oil Co., therefore, made a very thorough study of the treatment required for each of the refinery effluents. Surface waters from areas not likely to be con-



Combination-unit cat cracker and fractionator at Amoco's Yorktown refinery—showing the two waste-heat boilers suspended from main unit: Atmospheric distillation and crude vacuum towers are in right background. Vapor trail is by a jet from Langley Field (M. W. Kellogg photo).

taminated by oil are collected throughout the refinery by a grid of ditches. The water collected in this ditch system gravitates northeasterly across the refinery, and finally empties into the settling basin located in the northeast corner of the plant. All drainage from areas likely to be contaminated with oil, i.e., process paving, areas inside tank-dike firewalls, etc., drain into a common underground oily-water sewer. The drainage into the oily-water sewer is allowed to gravitate the entire length of the refinery into the API separator.

The API separator consists of two parallel concrete cells each designed to handle 2500 gal per min and so arranged as to permit uninterrupted operation of the separator while one cell is out of service for cleaning or repair. The wet oil which has been skimmed from the separator into a sump is pumped to the oil-recovery facilities located alongside the separator, where it is treated in two cascade dryers before being transferred to heavy-slop storage.

Effluent water from the API separator is largely process water which has been deaerated and has, therefore, very low oxygen content. It is, therefore, necessary to subject the effluent from the separator to further treatment which will restore its oxygen content before allowing this water to leave the refinery. Such treatment is provided by the oxidation pond, a shallow earthen-diked enclosure covering nearly five acres and identical in arrangement with the settling basin which is contiguous with and north of the pond. From its entrance into the pond, the water winds its way through the labyrinth of earthen dikes to the outfall sump. The large cross-sectional area of this flow reduces its velocity—thereby increasing the time of the surface exposure to sunlight and air from which the depleted oxygen content is replenished. When the condition of the oxidation-pond effluent is satisfactory, it is pumped from the outlet sump into the 60-in. cooling-water effluent stream which discharges from the offshore end of the dock 3,000 ft out into the York River.

A 20,000-bbl concrete holding basin is provided at the shore end of the dock to receive the oily waters of tanker ballast. This basin is designed as a circular separator in accordance with the design criteria set up by the American Petroleum Institute for a flow rate of 4,600 gal per min. The outlet of the sump is manifolded to permit drainage into either the settling basin or the API separator, depending upon the condition of the ballast water. The skimmed wet oil drains into the API separator wet-oil sump, from which it is pumped to the oil-recovery facilities already described. Of course, if the ballast is less than 20,000 bbl, the basin may be operated batchwise.

The sanitary sewer system is comprised of septic tanks located adjacent to the various buildings with the refinery. The effluent from these septic tanks flows by gravity into conveniently located collection sumps, from which it is pumped into the oily-water sewer system and undergoes the treatment already described for this latter sewer system. Sour gas from the process units will be treated along with other refinery tail gases in a gas-treating plant presently under construction by Fluor Corp. The treated gas is returned to the plant fuel system, and 50 tons per day of commercial-grade sulfur is recovered. When not treated, the sour gases are piped in a separate line from the process unit to the top of the 200-ft-high flare stack, and there burned in a special tip which is located in the pilot flame of the refinery flare. Spent caustic from the various process units is accumulated in storage tanks located near the dock. Its disposal is accomplished by pumping it into an emptied crude tanker at the dock. The vessel then dumps the solution far out at sea on its return trip.

The proximity of the new VEPCO generator station, with its looped tie-in to the utility's power transmission system, made available to the refiner an unlimited and very reliable source of electrical power. By placing full dependence upon this power source, spares for such large users as the FCCU air blower, gas compressor, etc., could be eliminated. This reduction in capital investment, when combined with the improvement in power rates resulting from the high demand factor of the large connected load tipped the economical balance in favor of all-electric drives over steam. The refinery power station is the hub for most of the utility distribution systems. The main electrical feeders from the utility-company substation terminate in the switchgear room from which all the branch feeders radiate to their loads throughout the refinery. The main steam-generating facilities are located here, as well as the plant and instrument air compressors, water-treating facilities, fire-pump and fresh-water storage tanks. With the exception of the switchgear, all of the equipment for these facilities is located outdoors—the layout being based essentially upon the "in-line" principle described for the combination unit further on in this article. The control panel in the refinery power-station control room includes the electrical distribution section, the boiler control section, and the supervisory panel for the remote control of the cooling-water pumps located at the VEPCO power plant. In addition to these main sections, there are the appropriate indicators and alarms for the various other untilities.

The refinery utilizes water from the York River on a one-through basis for process cooling. Because of the refinery's proximity to Chesapeake Bay, the composition of this water is essentially that of sea water. Three (3) 25,000-gpm vertically-driven pumps take suction from the river. Their discharges are manifolded into a 42-in.-diameter cast-iron bell-and-spigot buried line to the refinery. This line is concrete-lined to protect the cast iron from the corrosive action of the salt water and, incidentally, to improve the flow characteristics—thereby reducing the line size. The warmed cooling-water streams from the process units are manifolded into a 42-in.-diameter concrete lock-joint line which runs underground from the process area across the refinery and into the center of a 150-ft-diameter concrete-lined earthen basin located near the shore end of the dock. The purpose of this basin is to separate and recover oil leakage into the effluent stream before it enters the York River.

As mentioned earlier, the major portion of the refinery's products are transported to the various east coast market centers by tanker and barge. However, marketing facilities are provided for accommodating the marketing areas in the immediate vicinity of the refinery. The tank-car loading rack is served by the main railroad spur into the refinery. Stations are provided to permit the spotting and loading of 30 cars. The truck-loading facilities can accommodate four trucks at present. Displacement meters equipped with ticket printers record the quantity loaded through each nozzle. These facilities are served by a separate entrance from the main highway adjacent to the refinery—thereby eliminating product trucks from the traffic through the operating areas. Pumping facilities, centrally located with respect to the tank-car and truck-loading racks, take suction from the marketing storage located in the southeast corner of the refinery and load out the products at a maximum rate of 500 gpm for the rail cars and 250 gpm for the trucks (except that the loading rate for LPG is limited to 250 gpm for both truck and rail-car loading).

In addition to the foregoing facilities, the refinery is complete with airconditioned laboratory facilities and office space for operating, engineering, and management

personnel, as well as warehousing maintenance shops etc. Architecturally, the design of these buildings is clean, functional, and modern in appearance.

Even though America's premium gasoline Amoco, is unleaded, it never yielded in the current octane race. Since the current octane ratings of premium automotive gasolines are exceedingly high and are expected to go higher, the quality of the various components blended to produce Amoco's premium stock must be correspondingly high. To meet these high-quality specifications without an uneconomical sacrifice in yields or product distribution is, therefore, the task imposed on the refinery processing facilities whose heart is the combination unit.

The layout of the combination unit embodies the "in-line" system which has been developed by The M. W. Kellogg Co. and utilized so successfully in many other refineries as well as chemical plants. Based upon outdoor construction and the central control house, this design reduces not only the capital costs, but the operating costs as well. These advantages are attained without any sacrifice in either performance or flexibility. In fact the centralized control feature makes possible the optimum integration of the various sections of the unit and, therefore, their combined performance surpasses that of the old decentralized arrangements with their attendant communication limitations. Although a plant arranged in accordance with this plan becomes very compact, there is actually more working area and a far neater appearance than was possible with the older layouts. This is largely due to the simplicity and order inherent in the rectilinear patterns and to the tidy piping made possible by the central pipe avenue.

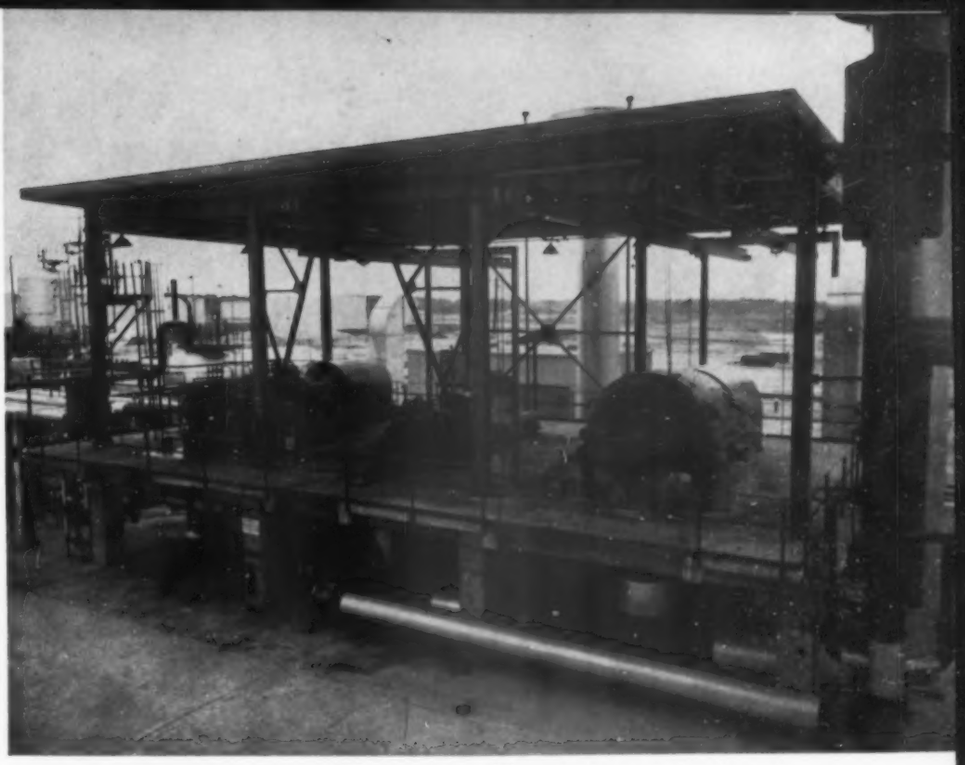
In addition to the operating advantages, this "in-line" design also facilitated the construction of this unit by permitting the installation of equipment as soon as it arrived at the job site. All areas of the unit were accessible either from the adjacent roads and access ways or by means of a single derrick crane located in the FCCU area—and, thus, no equipment setting sequence was necessary. This provided maximum flexibility for the construction operations—thereby minimizing construction costs and erection time.

Just as the layout permitted each piece of equipment to be installed whenever desired during construction, so it also allows several maintenance gangs to work simultaneously at various points in the unit without interferenec during busy turnaround periods. The result is not only in lower maintenance costs, but also less downtime. These same characteristics likewise make important contributions to plant safety. Fire-fighting equipment may be brought quickly to the point of blaze, which may be extinguished in comparative safety by virtue of the access roads within and around the unit.

Finally, the accessibility of all pieces of equipment, which leads to so many of the advantages mentioned above also contributes to simplified problems of modernization. In the future full advantage may be taken of any improvements in equipment design since this accessibility will permit the quick removal and replacement of any obsolete items. Piping changes, and the installation of new instruments and controls, can all be done with comparative ease. The combined effect of the "in-line" design was not only a saving in total plant investment and an earlier onstream date, but also a safe plant with lower operating costs than would have been possible with a less modern and more conventional type of plant layout.

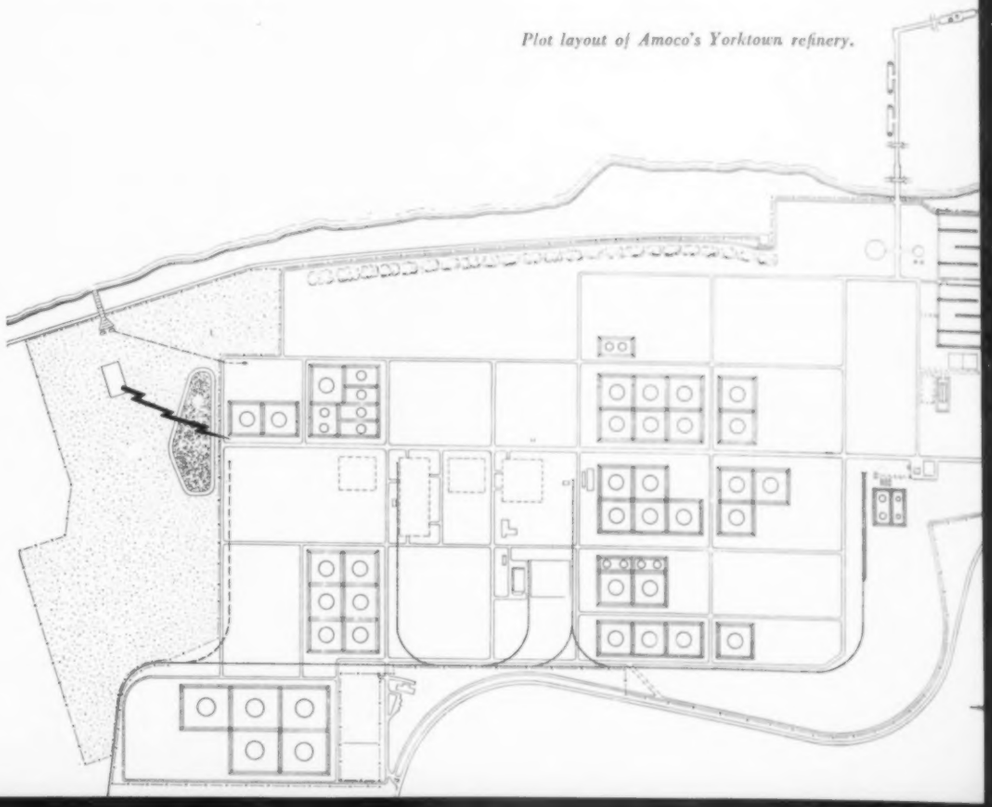
While it is evident from the foregoing description of the combination-unit layout and its processes that the design of these facilities embodies many desirable features, it is not "gold-plated" by any means. Operating convenience is inherent in the functional arrangement of the "in-line" design, and was, therefore, achieved while actually reducing costs.

The other process units were laid out with the same objectives with respect to safety, ease of operation and maintenance, and future changes and additions. END



The compressor shelter—showing main air blower, booster blower, and gas compressor for the cat cracker: All are of weatherproof construction. All suction and discharge lines enter and leave the shelter at grade—eliminating need for a pit (M. W. Kellogg photo).

Plot layout of Amoco's Yorktown refinery.



NEW TYPE REFORMING CATALYST TESTED

British Petroleum Company has increased the knock rating of the Platformate from its Kent refinery by three research numbers and leaded rating to 101 under more severe conditions and with a new catalyst.

THE Kent refinery of British Petroleum is one of the largest in the British Isles. When present additions are completed, it will be the company's largest refinery in this area. The first ground was broken for it on June 13, 1950, following selection and acquisition of a site on the River Medway side of the Isle of Grain. An engineer intimately connected with the construction of the refinery later summed up the project as a "forty-million-pound job with forty million headaches."

The story behind the location of additional "home" refining capacity for BP, then known as Anglo-Iranian Oil Co., was the increasing availability of Middle East crude, coupled with Britain's consumption of petroleum products far exceeding its existing domestic refinery capacity. In short, more domestic capacity was needed urgently to save scarce dollar exchange. After considerable investigation, it was decided that an entirely new refinery—preferably located somewhere along the Thames estuary—was desirable to cover the area of eastern England relatively distant from BP's existing refineries at Llandarcy, South Wales, as well as Grangemouth, in Scotland—the capacities of which also were being increased.

Of several locations along the Thames, the Isle of Grain was favored because of its convenience to the potentially large consuming area of metropolitan London and the fact that over 40 ft of water, even at lowest tides, was already available within a few feet of shore without dredging. One of the biggest problems to be overcome at the site was creating the proper footings for foundations of towers and other installations in the marshy ground of the location which had been deliberately chosen to minimize interference with centuries-old agricultural operations.

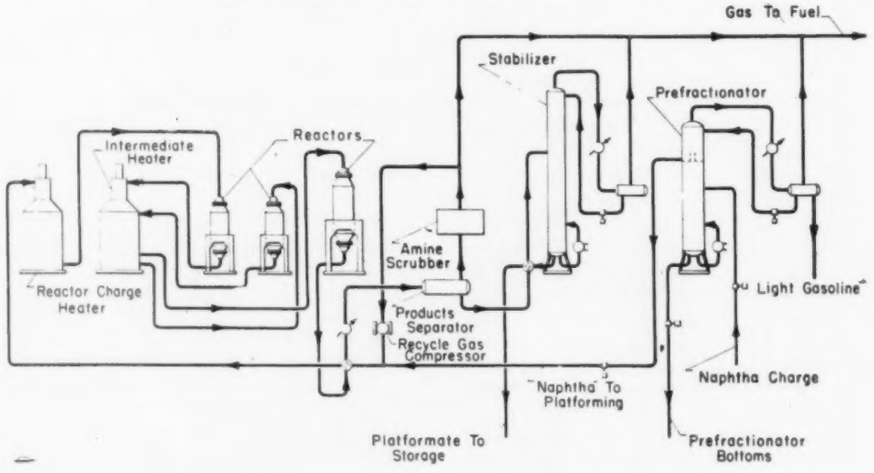
The "original" refinery consisted of a 90,000 b/d crude-installation unit—the largest in Europe at the time of its construction—and facilities for the production of lubricating oils in addition to motor spirits, kerosine, and fuel oils. Specialized units included two vacuum distillation units, each of 17,000 b/d capacity; a 10,000 b/d fluid catalytic cracking unit; an 8,150 b/d SO_2 extraction unit; a 4,500 b/d propane-deasphalting unit; a 5,800 b/d furfural-extraction unit; a 4,000 b/d MEK dewaxing unit; and 3,120 b/d of clay-contacting facilities. Four copper sweeteners, each of 8,000 b/d capacity, were installed to treat motor spirits and kerosine.

Just before the refinery was ready for commissioning, the great East Coast floods of January 1953 swept over the Isle of Grain. Most of the refinery was under water for nearly two weeks. This delayed completion, naturally; and the first units to operate in the plant were not commissioned until February 1953. The catalyst cracking unit, as well as some others, were commissioned as stage 2 in the autumn of 1953; while the lubricating-oil facilities, stage 3, were not completed until the summer of 1954. The 6,000 b/sd UOP Platforming unit—the first addition to the refinery—had been authorized for construction by this time, for completion in the spring of 1955.

British Petroleum now is increasing the crude-charging capacity at Kent to 140,000 b/d. With this 50,000 b/d expansion in basic throughput, a second Platforming unit of 10,000 b/sd capacity has been designed and licensed by UOP, and now is under construction. When this unit is completed and commissioned, the Kent refinery will have the greatest concentration of Platforming capacity in the United Kingdom.

BP's first Platformer at Kent was shut down last december during the Suez crisis after a run of over 200 days of producing 95 clear "research" octane Platformate from a Middle East naptha. This achievement was accomplished on a 6,000 b/sd unit of standard design through the use of one of Uni-

Fig. 1 Flow diagram of Platformer at Kent refinery.



versal Oil Products Co.'s new catalysts, R-8, which is tailored specifically for use in the production of super-octane motor fuels. The new catalyst, which is high in activity, is produced in England for refiners in the sterling area by Universal-Matthey Products Ltd., a subsidiary of UOP and Johnson, Matthey & Co. Ltd., London platinum refiners.

When the Platformer, a continuous nonregenerative unit, was shut down because of restrictions on crude supplies occasioned by the Suez developments, catalyst life had exceeded 42 bbl per pound during an uninterrupted run which had extended from April 29—a total of 226 days. At no time during this record-breaking performance did the clear octane number go below 94.8; most of the time it ranged from 95 to 95.7. When the unit was shut down, an analysis of current operating data indicated that catalyst activity and selectivity are still so satisfactory that plans have been made to resume operations with the same catalyst when adequate crude supplies are again available.

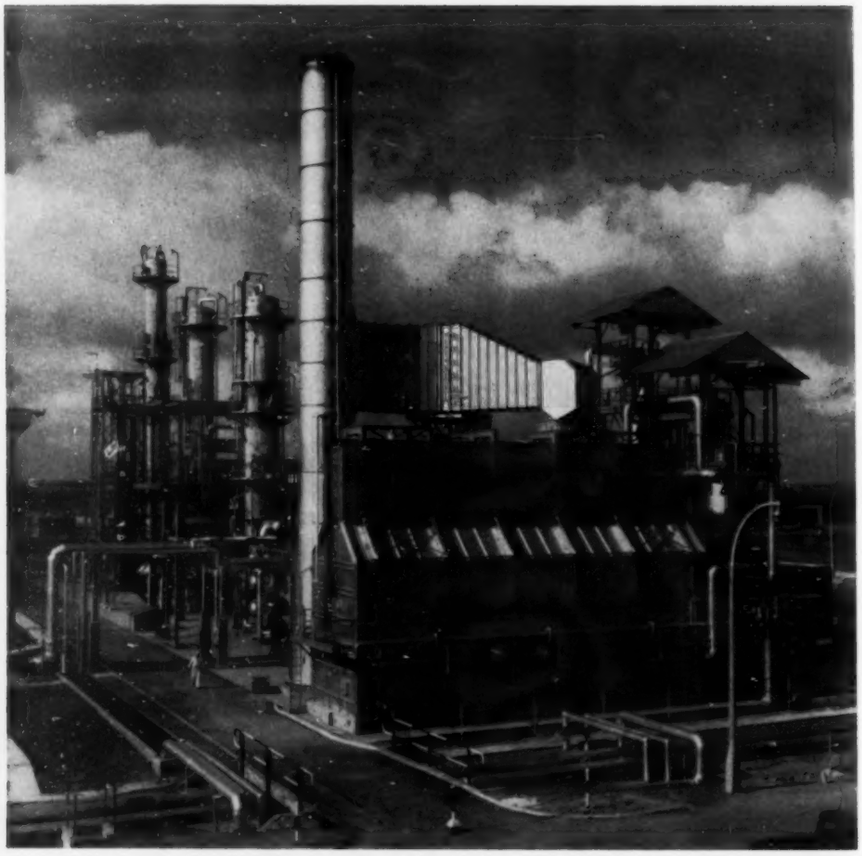
Another remarkable facet of this extraordinary run, which was scheduled to establish the performance of R-8 catalyst, was the yield obtained at operating conditions generally regarded as severe when compared to conventional catalytic reforming operations. A yield of 75% liquid by volume of 6-lb reid-vapor-pressure product on the reactor charge was obtained as an overall average in the run. Such a yield is regarded as quite satisfactory, economically, in view of the severe operating conditions employed.

Most outstanding, of course, in the overall picture is the fact that such a high octane number and longevity of catalyst were obtained in Platforming a naphtha derived from Middle East crude oil—for the most part of Kuwait origin. This Kuwait charge stock, predominantly paraffinic and comparatively low in napthenes, is regarded in world refining circles as being by no means the ideal charge stock for conversion to premium-quality products.

Catalytic reforming is becoming an important tool for European refiners because of a peculiarity in the markets supplied by European refiners which is not evident in markets served by North American refiners. In the first place, there is a greater dependence in Europe upon distillate stocks and residua, for space heating and power; there is practically no natural gas or LPGas available for these purposes. Hence, catalytic cracking plays a minor role—by American standards—in European refinery schemes because, there, it is not at all desirable to catalytically-crack a proportionately large volume of distillates into motor spirits. Thus, the primary source of motor fuel in Europe is straight-run naphthas which are poor in octane ratings and difficult to upgrade to the level of catalytically cracked gasoline.

Consequently, the problem for European

Overhead piping run at British Petroleum's Kent Platformer.



Heater and towers for British Petroleum's Platformer, which has a capacity of 250,000 tons per year and produces a high-grade motor-spirit component.

refiners is to convert the low-octane-quality straight-run napthas, without reducing the fuel-oil make by catalytic cracking, in order to meet the quality necessary to sell their petrol in the highly competitive local and export markets. By employing reforming, refiners not only obtain the necessary quality, but literally "build in" octane numbers to market requirements. Strongly conscious of this situation, British Petroleum wanted to assure itself that it would have the equipment to produce the highest octane-number gasoline which its markets would require in the foreseeable future—with due consideration to economy, stability, and simplicity of operation.

At the time the Kent Platformer was designed (it went onstream March 15, 1955) most of the installations then being built were intended consistently to produce a product having a clear octane rating of 80 to 85 "research." The upward trend in the octane quality of commercial motor spirits, however, has made it necessary for most Platformers to make a product testing appreciably above 85 "research" clear. Hence, the operation of the Platforming unit at Kent to produce a 95-octane clear Platformate, from a Kuwait naphtha, becomes of worldwide interest—particularly since the only major changes made to the original unit were new screens to accommodate the smaller-sized R-8 catalyst.

The ease with which the run with the R-8 type catalyst run was accomplished, and the extreme stability of the operation, indicate the potential for producing even higher octane numbers through conventional Platforming of poor stocks.

The Platformer consists of a prefractionator, reactor charge heater, reactor charge interheater, three reactors, a products separator, and a stabilizer. The hydrogen-rich product of the unit is passed through a conventional amine-type scrubber to remove hydrogen sulfide. This provides a sweet gas from which the hydrogen supply to the reactors is obtained. Other details of flow in this unit are shown schematically in Fig. 1, from which it will be seen that the installation is of essentially standard UOP design.

The charge stock to the reactors was a prefractionated Kuwait naphtha, a typical

Table 1
Inspections of Platformer Charge and Product (R-8 Catalyst)

	CHARGE		PRODUCT*	
Gravity, API	58.2	57.4	51.3	51.2
ASTM distillation, F:				
IBP	215	218	100	100
10%	232	236	138	139
30%	248	253	188	193
50%	264	270	238	246
70%	291	297	283	372
90%	318	324	327	348
EP	349	350	390	396
Reid vapor pressure, lb	—	—	6.4	6.6
Sulfur, % by weight	—	0.04		0.001
Hydrocarbon analysis, LV %:				
Paraffins	64			
Olefins	Trace			
Naphthenes	23			
Aromatics	13		49	49
Average yield of 95-octane:				
Clear Platformate, 6-lb-RVP, LV% on charge (2.5% C_6's)	—			75.0
Octane rating, Research:				
Clear	—		95.3	95.2
+3ml TEL per gal	—			101

*Stabilized.

Table 2
Inspections of Platformer Charge and Product (R-5 Catalyst)

	CHARGE		PRODUCT*	
Gravity, API	57.9	57.7	53.5	52.7
ASTM distillation, F:				
IBP	215	211	101	99
10%	237	236	140	152
30%	252	255	195	187
50%	270	275	221	238
70%	292	296	280	283
90%	315	320	323	325
EP	351	347	381	389
Reid vapor pressure, lb	—	—	6.3	6.4
Sulfur, % by weight		0.04		0.001
Hydrocarbon analysis, LV %:				
Paraffins	67		—	—
Olefins	Trace		—	—
Naphthenes	22		—	—
Aromatics	11		45	46
Average yield of 92-octane:				
Clear Platformate, 6-lb-RVP, LV% on charge	—			76.0
Octane rating, Research:				
Clear	—	—	92.2	92.5
+3 ml TEL per gal	—	—		100

*Stabilized.

analysis of which appears in Table 1. While this feed is not the lowest in naphthene content of commercially available naphthas, the characteristic concentration of these hydrocarbons in the low 20's marks it as a stock which is not ideal for Platforming to levels above 90 "research" clear. The data presented in Table 1 and Fig. 2 are the first to be published from a commercial Platformer reforming Kuwait naphtha over one of UOP's newest catalysts, R-8.

The inspections of charge stock and Platformate were taken from two different periods of the operation. The charge is shown as a 215- to 350-F-boiling-range material containing 23% by volume of naphthenes, 13% aromatics, and 64% paraffins. The first apparent conclusion concerning the Platformate is that it is a typical well balanced product from the standpoint of boiling range, and that the aromatic content has quadrupled. Since the increase in aromatic content is more than could be accounted for by conversion of all the original naphthenes to aromatics, the additional aromatics could have come only from aromatization of some of the paraffins.

The octane rating in these data ranges from 95.2 to 95.3 "research," unleaded. British Petroleum customarily uses the clear octane rating for daily control purposes. However, occasional tests indicate that this Platformate, when 3 ml TEL per gallon are added, will test well over 100-octane.

Some of the operating data from the recent run have been plotted in Fig. 1 against R-8 catalyst age in terms of barrels of reactor charge per pound of catalyst. Shown are the charge rate, Platformate clear octane rating, total reactor temperature drop, and gas production. Stability of the operation is suggested by the fact that octane rating varied by no more than one "research" octane number from the time the unit was lined out until the enforced shutdown. During this time, the individual reactor inlet temperatures (not plotted) were increased 20 F.

The total reactor temperature drop across all three reactors, or "Δt," obtained by adding together the individual reactor temperature drops, has been steady. Total Δt always is low when Platforming a Kuwait naphtha because of the small amount of naphthenes. Relative uniformity of the slope of the Δt curve and the nearly constant octane line give no evidence of excessive carbon deposition or other fouling of the catalyst which would indicate loss of activity and selectivity.

The plots of gas production from the separator and the stabilizer are of particular interest. The separator gas production is a nearly-straight horizontal line—indicating almost constant gas production throughout the run. The extremely gradual reduction in volume indicates that catalytic activity is diminishing quite slowly as the catalyst ages in use. This further emphasizes the earlier statement that there has been essentially no catalyst fouling from carbon deposition.

The production of stabilizer overhead gas is almost a mirror image of the separator

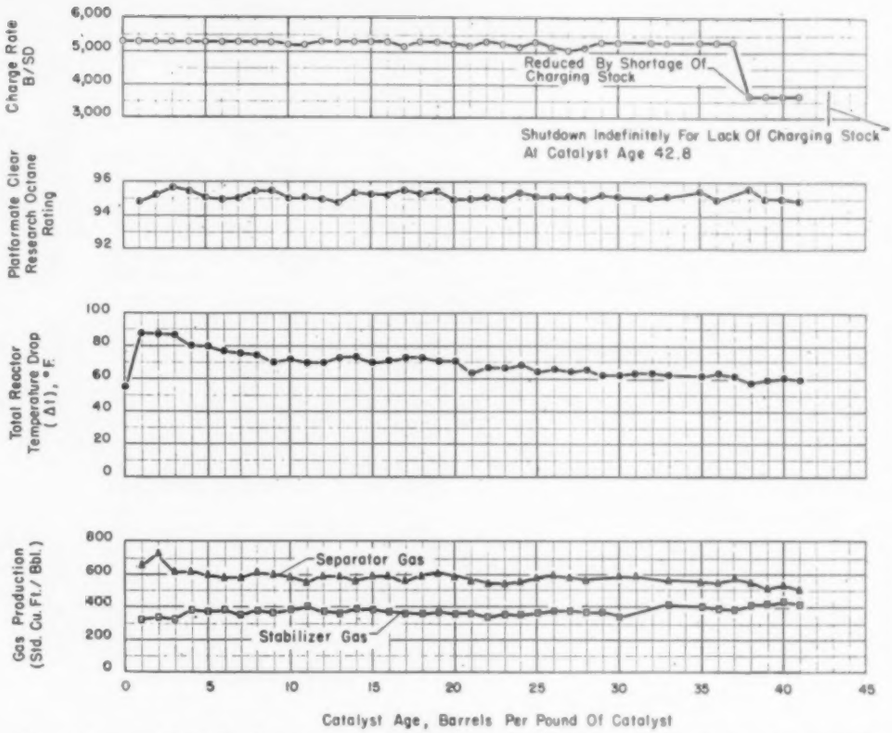
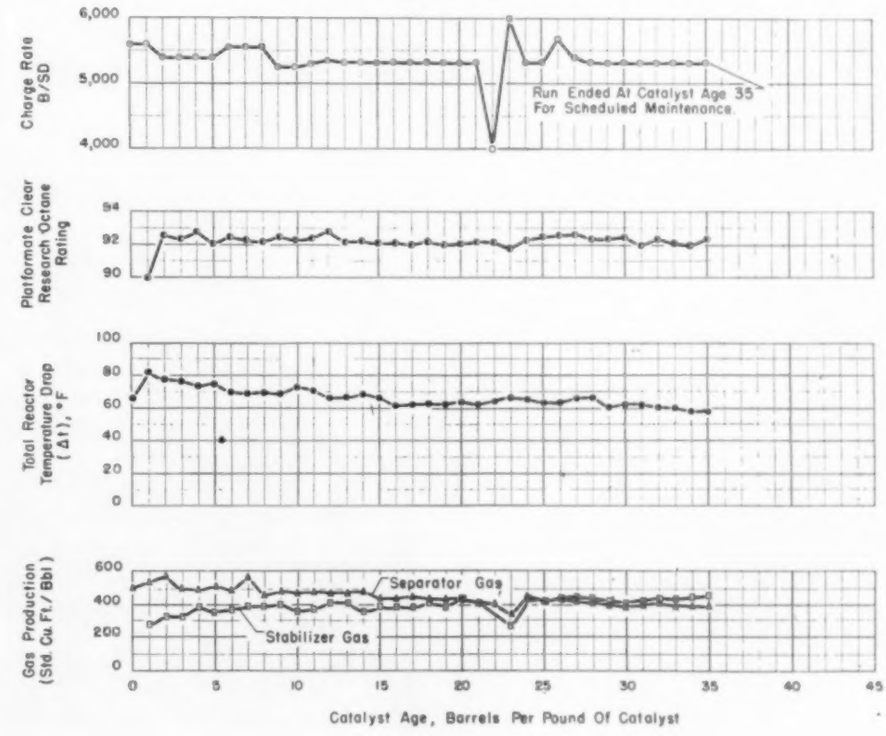


Fig. 2 Commercial Platforming of a Kuwait naphtha with UOP R-8 catalyst to 95-plus clear research octane number.

Fig. 3 Commercial Platforming of a Kuwait naphtha with UOP R-5 catalyst to 92-plus clear research octane number.



gas plot. This is evidence that there was little increase in hydrocracking—production generally having hovered within ± 55 standard cubic feet per barrel of the 375 scf/d mark virtually from the inception of the run. Taken together, the two plots of gas production pay tribute to superior operating techniques, also.

It will be noted that, beginning with catalyst age 38, there was an abrupt reduction in charge rate. The reduction was the initial result of the Suez unpleasantness, when crude supplies available to the refinery were curtailed. The data plots cease at catalyst age 41 because operating conditions in the unit were lowered to the 85 "research" octane clear level as a consequence of refinery wide changes in operation. The unit was shut down at catalyst age of about 42.8 for the same reason.

The data shown in Table 1 and Fig. 2 show that high-severity operations can be employed in a standard Platforming unit, on a "tough" charge stock, without economic penalty in terms of catalyst life, and that regeneration is unnecessary when employing a catalyst such as UOP type R-8, which is specifically intended for high-severity operations. As mentioned previously, even with 226 days onstream already behind it, Kent refinery officials intend to resume operations without changing the catalyst as soon as naphtha is available. Also, nothing beyond routine maintenance is planned for the unit during its enforced shutdown. It is not yet possible to estimate what the ultimate life of this catalyst charge will be at high-severity conditions.

The pattern for the R-8 run was foreshadowed by the previous run of the unit in which standard UOP type R-5 catalyst was employed—with good results on substantially the same Kuwait naphtha charge. Although the R-5 catalyst was not designed to produce an extremely high-octane product, the previous run—which lasted 142 onstream days—consistently produced a 92 F-1 clear octane Platformate at an average yield level of 76% by volume on reactor charge.

Table 2 presents inspections of typical charge and the Platformate made during the 142-day run with the R-5 catalyst—the same catalyst commonly used in Platforming units all over the Free World.

The charge stock had a boiling range of from 211 F to 350 F. It contains 0.04% by weight of sulfur, and the hydrocarbon-type distribution was 67% paraffins, 22% naphthenes, and 11% aromatics.

The typical Platformates shown had a boiling range of approximately 100 F to 390 F, and contained 45% to 46% aromatics. The concentration of naphthenes-plus-aromatics present in the charge does not account for the total aromaticity of the Platformate. These additional aromatics could only have come from aromatization of some of the paraffin hydrocarbons present in the charge.

The clear octane rating of the Platformate was consistently 92 or above. The yield average over the entire run was 76.0% by volume of reactor charge as a 6-lb RVP product. All of the inspection data in this table are based upon the total, stabilized Platformate—not merely the heavy, still higher-octane portion of the product.

Fig. 3 is a plot (against R-5 catalyst age) of charge rate, Platformate clear octane rating, total reactor temperature drop, and gas production. The charge rate and stabilized Platformate octane plots show that the operation remained stable as soon as the unit lined out. The conditions necessary to produce a product of the desired octane quality were determined in the field by the time catalyst age reached 2 bbl per lb. The stable nature of the run is further confirmed by the fact that the reactor inlet temperatures, which are not plotted, were increased only about 10 F over the entire run in order to maintain the desired product octane level. The abrupt fluctuations in charge rate indicated between catalyst age 21 and 24 bbl per lb are the result of shutting down the unit in order to repair a leaking overhead stabilizer condenser and then lining out the unit to steady operation at high severity again. During the shutdown, the reactors were sealed off and the catalyst left undisturbed in an atmosphere of hydrogen. The plot of total reactor temperature drop, or Δt, vs. catalyst age likewise attests to the stability of the operation, as indicated by the uniform, low rate of decline as the run progressed.

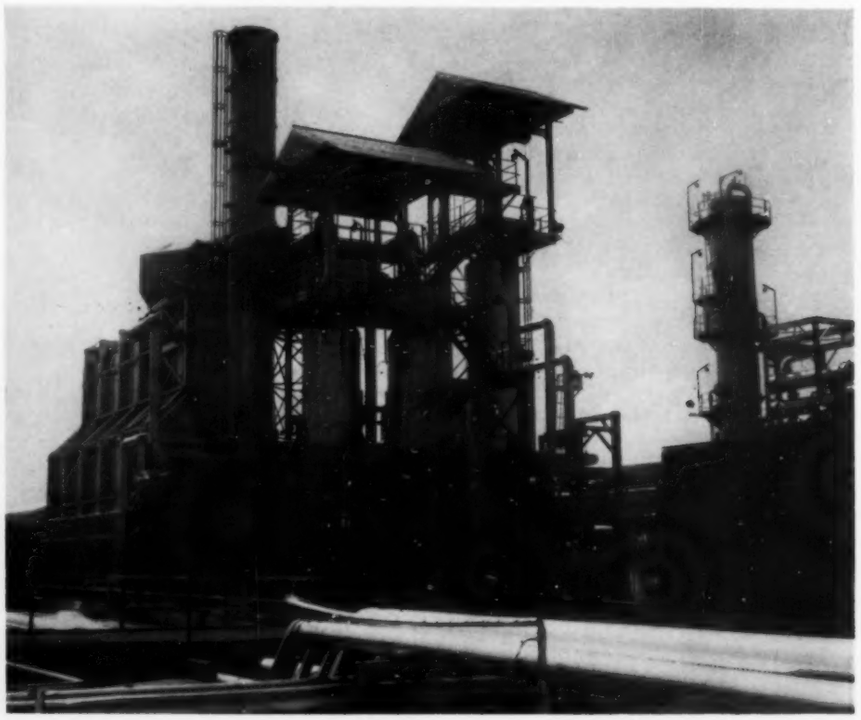
The quantity of separator gas and stabilizer overhead gas also are plotted vs. catalyst age in Fig. 3. The separator gas is particularly significant, since it represents the hydrogen-rich gas production of the unit. The gradual decrease in the volume of the separator gas is normally to be expected as the age of the catalyst increases. Likewise, the uniformity of the stabilizer-gas production shown is possible only in an inherently stable operation. The gradual increase in stabilizer-gas volume denotes a larger volume of light ends, and is due to a slight increase in the rate of hyrocracking.

This run, like that with the R-8 catalyst, shows quite clearly that there was no deactivation of the catalyst by excessive carbon formation. The uniformity of the separator gas line confirms that there has been no excessive drop in catalyst activity despite the severe operating conditions employed. That there was no excessive hydrocracking is portrayed by the uniformity of the stabilizer-gas volume.

This 142-day run was terminated, for scheduled inspection and maintenance, at a catalyst age of approximately 36 bbl per lb. Examination of the catalyst at this time showed that it was not fully spent despite the severity of the operating conditions which had been employed.

For reasons previously stated—notably the desire to produce a motor spirit of extremely high octane rating, even higher than the 92 octane clear of this run—British Petroleum elected to replace the still unspent R-5 catalyst with the then newly available R-8 catalyst. Accordingly, the necessary changes were made in reactor screens to accommodate the smaller-sized R-8 catalyst during this shutdown—the only major modification made in the physical equipment. Inspection of the balance of the facilities also showed that only normal wear and tear had occurred during this initial run. END

Reactors at British Petroleum Co.'s Kent Platformer.



Cracking installation at Shell's Berre refinery in the Greater Marseilles area. This 75,000-barrel plant ranks as one of the largest in France.

FRANCE NOW EUROPE'S SECOND LARGEST REFINER

by Guy Henry

Capacity of French refineries has increased 2,000% since the close of World War II, and is expected to more than double again by 1975.

THE treating capacity of French refineries has now passed 31 million tons (620,000 b/d), which puts France in second place among the oil-refining countries of Europe —just behind Britain. An accompanying chart shows the evaluation of this total capacity, which at the outbreak of World War II amounted to eight million tons and at the end of hostilities had fallen to 1.5 million tons. These results were attained at the cost of hard and continuous efforts on the part of the oil companies and French constructors of petroleum equipment of all kinds.

The tonnages of crude treated in 1956 rose to 26,801,000, against 25,086,000 tons in 1955, an increase of 6.8% in spite of the Suez incident. From this crude, the 13 refineries in operation obtained finished products as shown in Table I. It will be seen that more finished products were turned out in 1956 than in 1955.

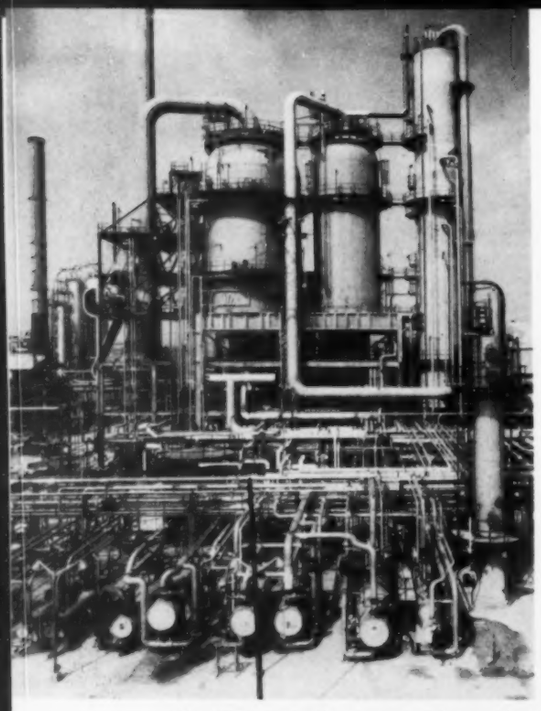
Consumption of finished products in the domestic market shows an appreciable increase as regards regular gasoline—3,029,000 tons in 1956 against 2,680,000 tons in 1955, an increase of more than 12%. On the other hand, premium motor fuel, consisting of the ternary mixture gasoline-alcohol-benzene, was 1,452,700 in 1956 against 1,549,400 tons in 1955, a decrease of 6.2%, as a consequence of the suppression of production of premium fuel in the last months of the year, due to events in the Middle East. Statistics relating to the earlier months of 1956 show that, contrary to what would have been expected as a result of new taxes on premium fuel, the curve of consumption of all gasoline was rising. Production of aviation gasoline in 1955 was 125,800 tons, against 159,500 tons in 1956. This increase was due to the starting up of several new catalytic units.

The most spectacular increase was in fuel-oil production—not only light fuel oils with 3,801,800 tons in 1956 against 3,355,000 tons in 1955, but also heavy fuel oils: 5,397,300 tons in 1956 against 4,848,900 tons in 1955. These increases were due to a hard winter in which French coal production, usually about 80 million tons, was only about 5.8 million tons; many industries took to burning bunker fuel; power stations put in more diesels, and railways began changing their locomotives from coal to bunker fuel.

Table II gives data relative to domestic consumption of the principal finished products in 1955 and 1956.

To these figures may be added the quantities delivered for maritime use: diesel oil (especially bunker oil) to French ships, 1,344,400 tons in 1956, against 1,293,200 tons in 1955; to foreign ships 674,400 tons, against 455,000 tons, an increase of 15% between the two years.

In 1956 imports of crude oil were 25,013,000 tons, against 24,738,000 tons in 1955; 90% of this crude came from the Middle



Fluid catalytic cracking unit recently completed at Gonfreville refinery of Cie. Française de Raffinage.

East. Of all nations in Europe, France is the most interested in the Middle East as a sure and regular source of supply.

Importations of finished products in 1956 reached 1,261,000 tons, against 942,000 tons in 1955—mostly in the form of certain kinds of fuel oils and aviation gasoline.

Exports of finished products (aside from those supplied to foreign ships) amounted to 4,966,000 tons, of which 50% went to Morocco, Tunisia, Algeria, and the French overseas territories; the other 50% went to various foreign countries.

In metropolitan France, production of crude oil amounted to 1,261,262 tons, which is not negligible in view of the domestic consumption of 17,600,000 tons of finished products. Most of this French crude oil (1,033,744 tons) came from the Parentis field, which in 1955 produced only 576,497 tons. At present this oil is being transported by water to the Port-Jerome refinery until the new Esso refinery near Bordeaux is put in service. North Africa produced 131,575 tons, of which 33,631 tons came from Algeria and 97,944 tons from Morocco; this north African oil was processed at the Petitjean refinery.

TABLE I

CRUDE RUNS TO STILLS BY FRENCH REFINERIES

(Millions of Tons)

		1955	1956
C.F.R.	La Mede	3,098	3,949
	Gonfreville	2,828	2,890
Antar P.A.	Donges	1,793	1,807
	Merkwiller	162	181
S.F. BP	Lavera	1,903	2,149
	Dunkerque	1,714	1,976
Shell-Berre	Berre	3,285	2,994
	Pauillac	438	657
	Petit-Couronne	2,093	2,311
Mobil Oil	Frontignan	946	975
	Gravenchon	611	736
Esso	Port-Jerome	3,143	3,328
Caltex	Ambes	1,031	1,032
Total		23,046	24,985

It is generally believed that consumption of petroleum products in France will continue to increase regularly, and that the total refining capacity in metropolitan France will progressively increase to 45 million—possibly 50 million tons—by 1963, and perhaps to 65 million tons in 1975. In view of these prospects, the existing refineries are giving thought to enlarging their equipment, and it is likely that new refineries will be built. Plans are already in preparation for a new refinery at Strassburg on the Rhine with a possible capacity of five million tons per year, which will include a plant for manufacture of detergents and synthetic rubber; but a decision on this location seems to depend on certain problems of economics and politics. It is also likely that a new refinery will be built in Algeria to treat crude from the Sahara, where rich finds of oil have raised high hopes.

The apparent necessity of the contemplated expansion has raised a question about the optimum capacity of individual plants in view of the fixed and proportional capacity costs. Heretofore the optimum plant capacity has been rated at about three million tons a year. But this is no longer true when it is desired to utilize certain refinery products as raw materials for the petroleum chemical industry. In that case, the optimum capacity approaches five million tons. For example, the butyl-rubber plant now building in the Basse-Seine which will use isobutylene furnished by two refineries having a joint capacity of seven million tons. In other words, the capacity of the existing refineries may be extended to four or five million tons, beyond which it will be more economical to build new refineries, if the plan of expanding the total refining capacity to 50 million tons is carried out.

As regards the national production, the year 1956 has been marked by exploration and construction carried out in the Lacq district, where the known reserves of gas now exceed 100 billion cubic meters. This gas field is perhaps the most difficult in the world to exploit because of high pressure, high temperature, and high content of hydrogen sulfide. The gas-bearing horizon lies at a depth of between 3,500 and 4,200 meters. The temperature at the bottom is 170 C (338 F), the pressure at the bottom is 630 kg/cm² (8,960 psi) and 550 kg/cm² (7.823 psi) at the top, and the content of hydrogen sulfide (H_2S) is more than 15%. These conditions require the use of especially designed or drilling equipment, and in particular a new special steel for the tubing; for this a chrome-aluminium-molybdenum has been found, and after some experience has appeared capable of satisfactorily meeting the situation.

TABLE II

OUTPUT OF FRENCH REFINERIES

(Millions of Tons)

	1955	1956
Liquefied gas	415.8	516.5
Aviation gasoline	135.8	159.5
Auto fuel	2,680.2	3,029.4
Super fuel	1,549.4	1,452.7
Special gasolines	52.8	61.4
White spirit	41.8	47.5
Kerosene	103.4	111.2
Special Carburant	78.3	97.1
Gas oil	1,500.1	1,554.2
Domestic fuel oil	1,407.8	1,913.0
Light fuel oil	1,627.7	1,888.8
Heavy fuel oils	4,848.9	5,397.3
Total fuel oils	7,884.4	9,199.1
Lubricants	427.5	486.6
Paraffin, waxes	16.0	18.8
Bitumen	861.4	899.3
	15,736.9	17,633.3

A first stage of a vast program for the exploitation of this field has been begun which contemplates treating a million cubic meters of gas per day. The expected production per year will include 200 million cubic meters of purified dry gas with a heat value of about 9,600 calories; 70,000 tons of sulfur, 12,700 cubic meters of gasoline, 4,200 tons of butane, and 3,200 tons of propane. The installations which make these products will operate under a pressure of 70 kg/cm², and will be connected with the producing wells through buried pipelines capable of withstanding a service pressure of 130 kg/cm² with a safety margin of 30 kg/cm²—all on the basis of a maximum output of 30,000 cubic meters. One pipeline will serve a maximum of three wells wherein the flow of gas through the pipes will not exceed 30 meters per second.

A second stage of exploitation of the Lacq program is contemplated for treating three million cubic meters per day; the arrangements for this stage will be completed before the end of 1958. A third and last stage for treating four billion cubic meters per year will come into operation at the end of 1962.

The Lacq field thus has a considerable importance to France. The present consumption of imported sulfur is about 110,000 tons per year, but by the end of next year the national production of sulfur will overtake consumption, and France may become a large exporter.

As regards gas, the reserves now known will be sufficient to supply, for a long time to come, the whole of metropolitan France in substitution for manufactured gas and coke-oven gas. In the current first stage in the exploitation of the Lacq gas field, the production is four times greater than the total present consumption of four such cities as Pau, Bayonne, Bordeaux, and Mont-de-Marsan combined. At the same time, the actual consumption of heavy fuel oils and coal in southwest France corresponds to 5.3 billions of therms. To this supply of heating materials the first stage of the Lacq operations is prepared to add two billion therms.

A network of pipelines for distribution of gas throughout southwestern France is coming into existence, and important projects are under study for carrying the gas to Nantes, Le Creusot, and perhaps also to the region of Paris.

On the whole, the Lacq gas field has been a godsend to the relatively underdeveloped Southwest, and also to all of France because of the large reduction of the nation's power deficit.

Another event in the general plan for

1956 was confirmation of the rich discoveries in the Sahara, at Edjele, near the Lybian fronteir; at Tiguentourine, and at Hassi-Messaoud. By the first of next year arrangements will be made for transporting to the Algerian coast 500,000 tons of crude per year; this will be a provisional installation pending a definitive plan for development of the three fields just mentioned. This plan, which will be spread over three years, will require an investment of about 250 billion francs. Some 300 wells will be needed to produce four million tons per year at Edjele, 60 wells, for five million tons at Hassi-Messaoud, to be completed by end of 1959. This estimated production is counted on for a saving on the order of 70 billion francs of foreign exchange. The permanent pipelines which will transport the African oil will probably have their termini on the coast of the Gulf of Tunisia, and perhaps also on the Algerian coast, where a refinery will be built along with a blast furnace to treat local iron ore. Hassi-Messaoud will also supply several billion cubic meters of natural gas. The French are evidently attaching great importance to these factors of economic expansion in North Africa.

As a whole, all the programs, evaluated in francs, will involve 600 billions up to the end of 1961.

Since the war, the reconstitution of means for storage and distribution has advanced on a par with the expansion of the refineries at the needs of the consumers. The refineries now have storage for about six million cubic meters, and for 2,800,000 cubic meters pertaining to about 1,000 distribution centers, among which there are 125 units capable of holding 5,000 cubic meters or more. Floating-roof tanks have been built under American licenses, and a French company has patented a new type of floating roof, using a plastic material which seems to be giving complete satisfaction.

At the end of 1956 distribution equipment included 5,600 trucks, 11,500 tank wagons, 650 barge tankers, 35 vessels for the coastal trade. There are 95 tankships plying the high seas, with a total capacity of 1,939,160 deadweight tons, which transport under the French flag 65% of the nation's oil exports and imports.

There are now under construction or on order 44 tankers totaling 1,750,000 tons deadweight (as against one million dwt at the middle of 1956), averaging 39,740 tons per ship. This tanker-building program will extend up to 1963. Among the latest to be contracted for are some of 50,000 tons capacity. In 1957 there will be launched six tankers totaling 258,000 tons, of which one is for 49,500 tons and one for 52,000 tons. Some of the French ports are equipped to handle these big ships, and the port of Havre will soon be in position to take tankers up to 100,000 tons.

It may be noted that, for the retail trade, there are 64,000 roadside pumps included in 40,000 local gasoline stations. The French park of automotive vehicles on January 1, 1956 (the actual figures are not yet available) was 3,351,307, but the total should now be near 3,600,000. At least half of these entered circulation since 1952, and the age of those in service seems to be becoming shorter. Nearly 22% of all these vehicles are in the Paris region.

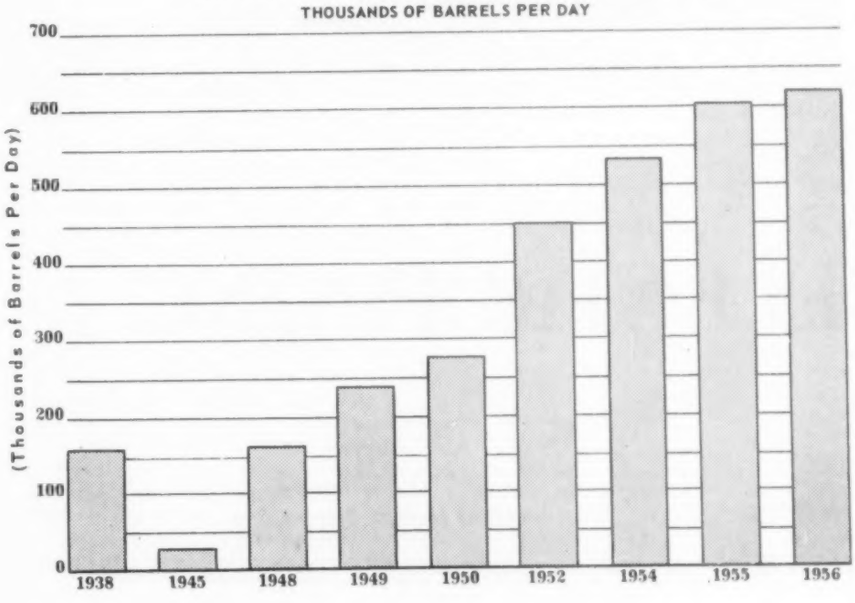
One point should be underscored: It is that all the equipment mentioned herein was furnished and installed by French constructors. This was already the case for distribution equipment before the war; trucks, boats, tank wagons—all were of French design. And it is now also the case with refinery equipment; for example, pumps for hot oil are being made in France; also, tubular and insulation material, oil-furnace headers, control apparatus, etc. Of course, a certain number of these elements are being fabricated under American license; for example, tubular exchangers, for which a number of large shops are being familiarized according to the specifications of TEMA. Most of the apparatus still being imported are of types for which the demand on the French market is too small to induce investment in their manufacture; for example, slide valves, certain control mechanisms, special apparatus for gas analysis, etc.

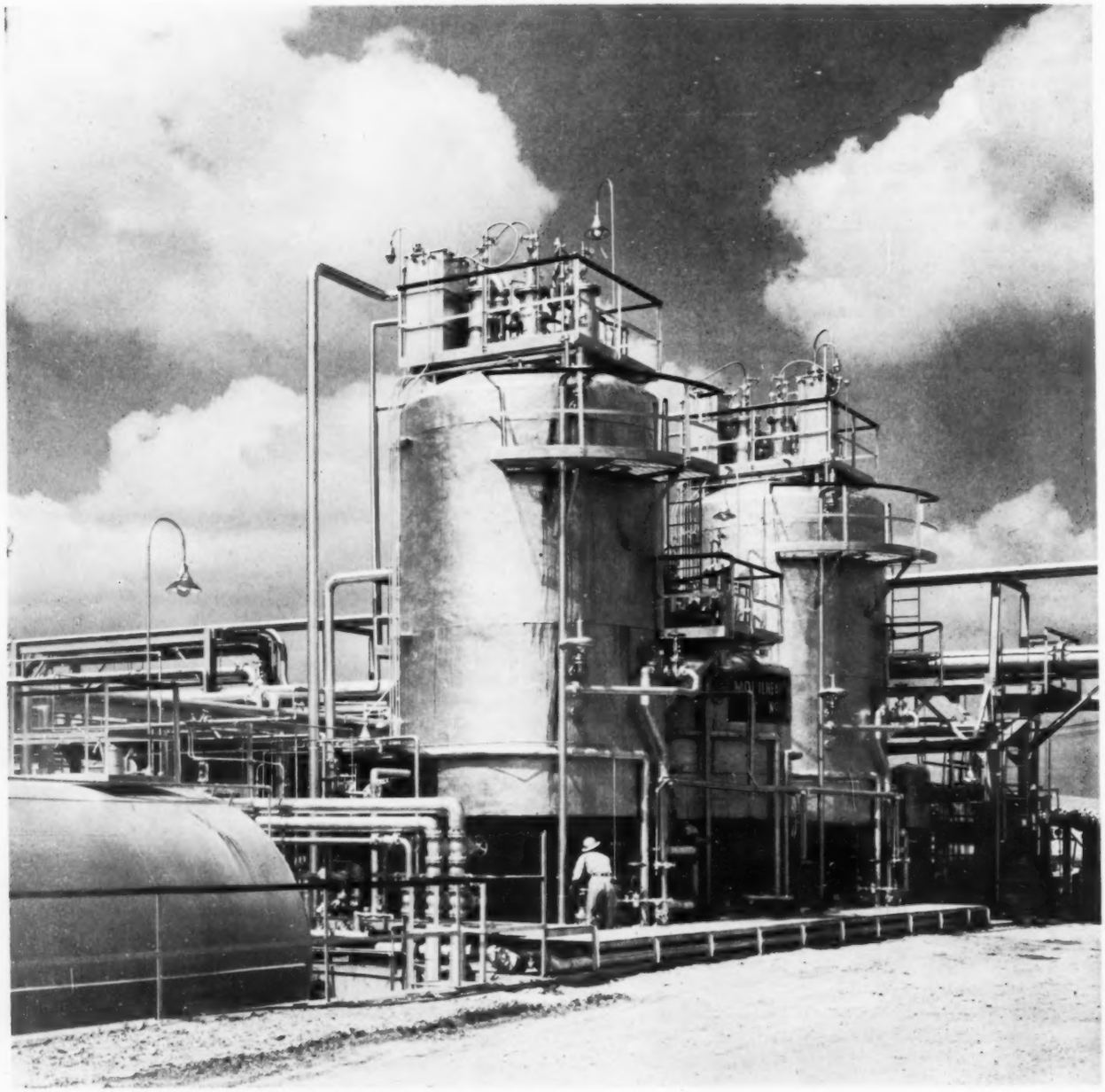
However that may be, these results have been due to the close cooperation between the refineries and their technical advisers —nearly all of them Americans—and the French constructors, who have familiarized themselves with American specifications—notably those of the American Society for Testing Materials—in order to meet the requirements of their customers. This adaptation has demanded great effort to match French ideas of quality with the qualities which the Americans have put into the design of American installations.

Another fact confirms the quality of French oil equipment: The results attained in the export field, not only in the matters of tankage, distilling columns, furnaces, or electrical equipment, but also in complete installations for storing and distribution parks and depots, pipelines, and complete facilities for refining; an example is the Cubatao refinery in Brazil which was entirely built and installed by French groups; also the refinery now under construction in Finland, which for the most part will be implemented by a large French company.

All this shows that, in a petroleum industry which is in constant evolution, the constructors in this country are in a position to supply the same grade of equipment which is demanded in France and in its overseas territories. END

Detail of one segment of Fives-Lille rotary filter ready for installation at the Notre Dame de Gravenschon refinery of Mobil Oil Française.





Petreco Electrofiner for Treating Catalytic Cycle Oil.

ELECTROFINING

by R. W. Stenzel*

developed as a treating method to help the refiner meet problems posed by modern catalytic conversion processes

**Petreco Division, Petrolite Corp., Long Beach, Calif.*

Dr. R. W. Stenzel received his undergraduate training at the California Institute of Technology, and his Ph.D. from the University of Michigan. He has been engaged in research activity in the petroleum industry for 20 years, and was formerly director of research for the Petreco Division of Petrolite Corp. For the past 10 years he has acted as a consultant for this organization.

MODERN demands on the refinery for continually improved refinery products have been so great that conventional methods satisfactory in the past are no longer adequate. Therefore, it has been necessary to develop new processes which can meet these increasing requirements for greater product quality.

In the United States the thirst for power in motor cars by the American public has not as yet reached a limit, even at the present almost fantastic proportions, and the refiner has been hard-pressed to meet the corresponding demand for gasolines of higher and higher octane numbers. In most other countries the trend has been more in the direction of economy, since gasoline costs are usually higher, and high horsepower ratings mean higher taxes on the vehicle. As a consequence, the pressure for higher-octane motor gasolines outside the United States has not been nearly so great, and this, of course, means that the refining requirements for products will be considerably different in the world markets in general as compared with the United States. It is also noteworthy that, with the advent of turbine and jet-propelled motive power for airplanes, the trend in aviation fuels will in the future be away from high-octane gasolines.

Furthermore, refiners everywhere are being pressed to increase the quality of their products in the range of kerosine, diesel oils, burning oils, gas oils, etc., so that these will be color-stable, neutral; will not form gums upon standing; and will have low sulfur, nitrogen, and metal contents, etc.

To meet these demands, the refiner has been forced to adopt more drastic and more desirable processing methods—the most outstanding of which are the catalytic conversion processes, such as catalytic cracking and reforming. However, this type of operation has created new problems because the catalysts are notoriously susceptible to poisoning by various impurities present in the charging stocks. The refiner is, therefore, required to prepare better products not only for the market, but also for his own additional refining steps.

Briefly, the impurities in crude oil and distillates of greatest present concern to the refiner may be classified as follows: water, salts, sediments, sulfur, acids (naphthenic acids), nonacidic oxygen compounds (resins, cresols, etc.), nitrogen compounds, organometallic compounds (vanadium, nickel, iron, arsenic, etc.).

Water, salt, and sediment, being oil-insoluble materials, are readily removed from crude oil before it is distilled by efficient desalting operations. The importance of reducing these substances to very low quantities, say less than 5 lb per 1,000 bbl barrels, is now well recognized by refiners, and these processes need not be described here.

The oil-soluble impurities cannot be removed by desalting methods, and they find their way into the distillation and cracking products in various proportions. In straight-run operations, the greater proportion of each impurity remains in the residue; but, if this residue is subsequently subjected to thermal cracking, there will be thermal decomposition also of the impurities, and the products will then contain much larger amounts than the straight-run products. This is illustrated by the high sulfur contents of cracked gasolines, for example.

A brief description of the various kinds of impurities typically found in petroleum fractions from distillation or cracking operations will indicate the nature of the problems encountered by the refiner.

Naphthenic acids are oxygen compounds, and are found distributed throughout the various distillation products—although the larger portions will be left in the residum from atmospheric and vacuum distillation. Because of their acidic nature, these materials are corrosive and are, therefore, desirably removed from the distillates. The acids present in the lighter distillates are in considerable demand for industrial use, and by a appropriate caustic wash the refiner cannot only purify the distillate, but he can also make a profit from the recovered impurity itself.

Nitrogen compounds have been of particular concern to the refiner in the past two years because of their severe poisoning action on catalysts. This is true not only of the platinum catalysts used in reforming operations, but also those of catalytic cracking processes. The presence of nitrogen bases in catalytic cracking charge stocks can cause a reduction in gasoline yield by as much as 20% in operations utilizing stocks from crudes such as those of California where the nitrogen contents are rather high. Coke formation and gas production are also increased, so that the economic losses caused by the presence of nitrogen can be considerable. In the case of reformers, if the nitrogen content of charge stocks is more than a few parts per million, serious catalyst poisoning is also encountered.

Nitrogen occurs in the products of straight-run distillation in the form of both basic and nonbasic compounds—the basic form usually being about 25% of the total. On the other hand, both thermal and catalytic cracking operations will convert most of the nitrogen into basic compounds. These are then quite susceptible to removal by acid-washing procedures. It should also be noted that the nitrogen content in the products from cracking operations is considerably higher than in the corresponding straight-run materials produced from the same stock.

Sulfur has always been an undesirable constituent of refinery products, and many methods have been devised to remove it to satisfactorily low quantities in the various refinery streams. The amount of sulfur which will find its way into the overhead distillates depends largely upon the source of the crude and the severity of the decomposition employed. The presence of sulfur in gasoline streams is now of increasing concern because of its adverse effects on octane ratings and lead susceptibility. Furthermore, it is now considered highly desirable to reduce the sulfur content of reformer charge stocks to as low a value as possible because it seriously affects the selectivity of platinum catalysts.

Organometallic compounds have been known to be present in crude oils for many years, but until the advent of catalytic processing they have been of comparatively

minor concern to the refiner. However, the heavy metals—such as vanadium, nickel, copper, and iron—are now known to be the cause of severe catalyst poisoning both in catalytic cracking and reforming processes and are, therefore, desirably kept to very low levels. Arsenic is a very powerful platinum poison, as also is lead, which often finds its way into reforming charge stocks by contamination from tanks and admixtures where tetraethyl lead has been used. The effect of arsenic on platinum is so great that it must not be present in quantities more than a few parts per billion, to avoid serious reduction in catalytic activity. The heavy metals present in crude oils are usually considered to be in the form of chelated organometallic complexes, principally associated with the high-boiling fractions and the residues from distillation. However, an objectionable portion of these metals usually finds its way into the overhead products.

Alkali metals: As has been previously mentioned, substances not connate with the oil, such as lead, are introduced as impurities in the refinery itself—and this applies also to the alkali metals. These are present in distillates usually as a result of an alkali-treating process and occur in the form of residual caustic or alkali metal soaps. Since the alkalies are strong poisons to cracking and reforming catalysts, they cannot be tolerated in materials charged to these processes in quantities greater than 1 ppm or 2 ppm. Refiners now generally require maximum limits ranging from 0.5 ppm to 2 ppm.

The problem confronting the refiner who must combat impurities of the types mentioned above in his products (and there appear to be none who are not so confronted) is to find the best process which will also be the most economical for reducing these impurities to limits which can be tolerated either by the marketing specifications or by his own additional processing requirements. A very effective method for removing these impurities is the recently commercialized hydrotreating process. This utilizes hydrogen under elevated temperature and pressure conditions to hydrogenate the impurity-containing compounds—releasing sulfur, nitrogen, and oxygen in the form of gaseous components, such as hydrogen sulfide, ammonia, and water vapor, which carry little or no hydrocarbons from the system. Metals are removed by deposition on the catalyst, and unsaturated hydrocarbons are hydrogenated. The process is principally applied to distillates, but in some instances even to the crude oil itself.

Alternatively, chemical treatments such as washing the distillates with acids and alkalis can be used for purification. The older methods of treating with sulfuric acid and caustic soda consisted simply of mixing the chemical with the oil and allowing the mixture to separate by gravity. However, such procedures are no longer adequate for the high degree of purity of oil and efficient utilization of chemical which the refiner now demands. Gravity settling is usually quite inefficient—because, if mixing is so intense that complete reaction between the reagent and oil takes place, the emulsion formed is so fine that it will not separate in a reasonable length of time, and sometimes not at all, so that residual caustic or soap is carried over into the treated product. On the other hand, if very gentle mixing is used, settling may be adequate, but efficiency of the reaction is so poor that much of the reagent is wasted. Overhead carry-over cannot be tolerated if the oil is to be used for diesel fuel or burning purposes or if it is to be charged to a catalytic process, and poor utilization of the acid or caustic means high chemical costs.

These deficiencies led the Petreco organization to develop the Electrofining process, which is essentially a combination of chemical and electrical methods to produce the degree and kind of purification demanded by modern refining practice. The flow diagram herein depicts an acid-alkali type of treatment of a distillate by this process, utilizing a dual-stage operation in the same treating vessel. The plant requires very little attention because automatic controls maintain all preset conditions, such as flow rates and interface levels, at constant values. Some of the controls also actuate warning and signaling systems in operation. The residual acidity from the first electric precipitation stage is often so low that complete neutralization can be achieved by a simple water-mixing step in which a little caustic is added to maintain the pH of the effluent water slightly on the alkaline side. This caustic addition may be controlled manually or by a pH controller.

In general, appropriate chemical reagents, such as acids and alkalies, are emulsified with the oils to react with the undesirable constituents, and the powerful coalescing forces of the electric field are utilized to produce virtually complete removal of the reaction products from the oil in an extremely short time. This results in a number of outstanding advantages over the older treating procedures. In the first place, it is possible to mix the reagent with the oil very intimately by suitable emulsifying techniques, so that a maximum possible contact between oil and reagent can take place and maximum reaction or extraction achieved. The coalescing potency of the electric field avoids any separation problems. In older processes, it was usually necessary to use large excesses of the reagent because the gentle mixing made necessary by slow settling characteristics could produce only incomplete contact. Furthermore, the per cent by volume of the reagent had to be high, often 5% to 10% or more, to provide a system having reasonable sedimentation times. This means that recirculation is required to avoid excessive waste of the reagent, but this often leads to difficulties because stabilizing materials tend to build up in the system, and these gradually produce emulsions which are increasingly difficult to separate. It should be noted that efficient utilization of chemical reagents can be an important factor in reducing pollution problems in refineries, as well as producing appreciable savings in the chemicals themselves. In Electrofining with caustic, for example, it is usually necessary to add only a slight excess over the equivalent amount required, and no recirculation is necessary. The rapid coalescence produced by the electric field also avoids entrainment of oil in the reagent phase, thereby preventing product loss and contamination of the settled material. The coalescing action is so rapid that comparatively small vessels can be used as electric treaters—thus saving installation costs, piping, etc.

Whether the refiner chooses the hydrotreating or the Electrofining type of process for purifying his oil depends on a number of factors. In the first place, the process must be able to accomplish the degree of refinement required by market or processing specification—and then, of course, the processing must be economically justifiable. Hydrotreating requires, first of all, a cheap source of hydrogen, which currently can only be made available when reforming operations are being conducted on the refiner's gasoline streams. Hydrotreating equipment and operating costs are rather high, and they become even more so if the treating severity needs to be high because of the presence of some types of impurities, such as nitrogen, which are difficult to remove. Such a process, therefore, can be justified only when less drastic methods are unable to accomplish the required degree of purification.

The applicability of the chemical-electrical processes represented by Electrofining, together with some of its limitations, may be briefly delineated as follows: Straight-run distillates can be treated with caustic to remove acids, hydrogen sulfide, the lighter mercaptans, and gum-forming constituents. In cracked products, cresols and thio-cresols (sometimes classified as "tarry acids") can be readily removed with strong caustic solutions. Sulfuric acid can remove sulfur compounds and gum-forming constituents, nitrogen bases, and in many cases metals such as arsenic, lead, etc. Spent alkylation acid has been found to be particularly suitable for acid treatment—first, because of its low cost and, second, because it is effective in removing impurities without reacting with desirable hydrocarbon constituents such as the olefins, which are present in thermally and catalytically cracked distillates. Sulfur can be removed from distillates by sulfuric acid to the extent of 50% to 75% with reasonable dosages, such as 5 to 10 lb per bbl. If greater sulfur removal is essential, the required acid dosages often become prohibitive.

In order to show the versatility of the Electrofining process to refinery operations, Tables I, II, and III have been prepared. This appears to be the simplest manner of indicating the products which are treated and the results to be achieved. The tables show the three categories under which the treated products are most usefully classified.

TABLE I
ELECTROFINING OF DISTILLATES FOR THE MARKET

Products Usually Treated	*Object of Treatment*	*Product Quality Produced*
Naphthas	Sulfur removal	Sweet
Gasoline	Acid removal	Low-sulfur
Kerosine	Base removal	Neutral
Jet fuel	Gum removal	Bright
Diesel oils	Color-stable	Color-stable
Burning oils	Metals removal	Nonemulsifying
Spray Oils	Sludge removal	Compatible
Lube oils		

TABLE II
ELECTROFINING OF DISTILLATES FOR REFORMING

Products Usually Treated	*Object of Treatment*	*Effect of Treatment*
Naphthas	Sulfur removal	Minimizes catalyst poisoning
	Metals removal	
	Nitrogen removal	Improves product quality

TABLE III
ELECTROFINING OF DISTILLATES FOR HYDROTREATING

Products Usually Treated	*Object of Treatment*	*Effect of Treatment*
Naphthas	Reduce sulfur	Reduces severity required on hydrotreater
Cycle oils	Remove nitrogen	
Gas oils	Remove arsenic	Reduces catalyst poisoning
	Remove other metals	Reduces equipment cost

Case Histories: It is impossible in a limited space to describe all of the applications which have been made of Electrofining on the great variety of refinery products which have been listed in the tables. It usually turns out that each problem has its own particular requirements which differ considerably from others in the same refinery or in different refineries. Consequently, each problem must be studied and treated individually and the process tailored to produce the maximum quality improvement. The Electrofining process has been applied to straight-run, vacuum-still, catalytic cracking, and thermal cracking products of greatly varying characteristics, and has been used to prepare these products for the market, for reforming operations, for catalytic cracking, and for hydrotreating processes. The principal purpose is to remove impurities which otherwise produce undesirable qualities in the finished product, either directly or as a result of poisoning of catalysts used in their processing.

In order to show the wide utility of the Electrofining process, a few examples of commercial operations are shown below:

Brief case histories of electrofining operations include—

Preparation for Market:

A. JET FUEL: Electrofined with 1 lb per bbl of spent alkylation acid, followed with a dilute caustic (2-3 Be') wash. Mercaptans reduced from 0.009% to 0.005%. Color stabilized. Meets water-tolerance test and other jet-fuel specifications.

B. DIESEL FUEL (straight-run): Electrofined with dilute caustic (4° Be') and water-washed. Naphthenic acids and polymerizable materials removed. Passes "Atlantic crossing" test for sediment formation.

C. LUBE OILS: Electrofined with strong acids and acid sludges to remove resins and stabilize color. Contact time minimized, and oil entrainment in sludge eliminated.

D. EDELEANU PLANT RAFFINATE AND EXTRACT: Electrofined with dilute caustic to neutralize. Neutralization number in raffinate reduced from 0.5 to 0.01, and in extract from 1.71 to 0.08.

E. CATALYTIC CYCLE OIL: Electrofined with strong caustic followed by water wash to remove tarry acids, stabilize color, and prevent sediment formation. Product is neutral.

Preparation for Hydrotreating:

F. COKER NAPHTHA: Electrofined with 0.5 lb per bbl of spent alkylation acid, removing nitrogen from 120 ppm to 5 ppm, with less than 0.5% distillate loss and very little change in olefin-aromatic-paraffin ratio. The absence of nitrogen permits operation of the hydrotreater at low severity, and minimizes exchanger fouling. This is an important economic saving.

Preparation for Reforming (platinum catalyst type):

G. NAPHTHA (straight-run): Electrofined with 1 lb per bbl of spent alkylation acid, followed by a slightly alkaline water wash. Arsenic is reduced from 100 parts per billion to 4 ppb. Lead from 600 ppb to 20 ppb. Sulfur from 0.028% to 0.015%. Catalyst life is greatly increased, octane numbers improved, and yield increased about 30%.

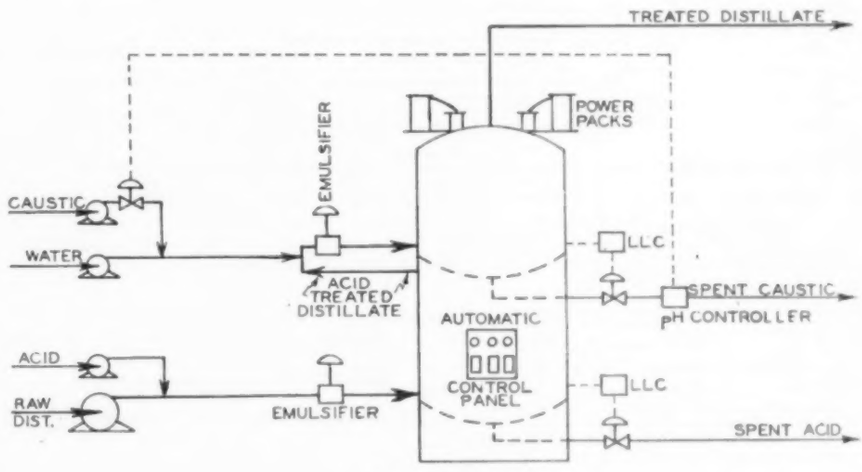
H. LIGHT GAS OIL (from hydrotreater): Electrofined with caustic to remove hydrogen sulfide and tarry acids.

This brief description shows that Electrofining processing, as developed by the Petreco Division of the Petrolite Corp., is a versatile method and applicable to many refinery streams and at various points in the refining process. In addition to purifying products for the market, it can be used to prepare them for reforming; or, when used in conjunction with hydrotreating, either before or after that process (operations "F" and "H" above). Each application requires individual study to provide the best and, at the same time, the most economical processing for the refiner's purposes. It should be pointed out that, in all cases where caustic solutions are employed, the residual alkali metal in the treated product is extremely low and well within the specification requirements.

It is interesting to note that operation "D" represents a South American and operation "E" a Canadian installation. The other operations described represent United States installations.

In general, the cost of Electrofining equipment is quite modest as refinery equipment goes. As in the case of general refinery operations, the type of oil used, the severity of treatment as reflected by the amount of the reagent required, and other factors will influence the cost of any particular installation. Normally, the cost per barrel of installed capacity will be in the range of $2 to $20 per treating unit—the lower figures being applicable to the light distillates, such as naphthas and jet fuels, and the higher ones to the heavier gas oils. In the same manner, the operating costs will be in the range of 0.2 cent to 2 cents per barrel for chemical and power costs. It should be noted that these costs are approximately one-tenth those for hydrotreating the same distillate streams. The power requirements for the electric fields established in the equipment are very small, since the transformers usually use less than 1 kw, even at the high voltages applied. The chemical costs, of course, depend upon the particular reagents required for the operation. Since it is often desirable to use a 2-stage system such as caustic treating followed by water washing, or acid plus alkali treatment, Electrofining equipment is available in double-deck arrangement of a single vessel, which is especially advantageous where there are space limitations. For the case of lube distillates, the lower throughput rates of these viscous materials calls for larger-sized treaters and correspondingly somewhat higher costs.

The photo, "Petreco Electrofiner for Treating Catalytic Cycle Oil," shows the type of equipment used in Electrofining operations, each of the two treaters having a double-deck arrangement, so that the distillate (in this case a catalytic cycle oil) is treated with caustic in the first stage and with water in the second. This is the plant briefly described as operation "E." END



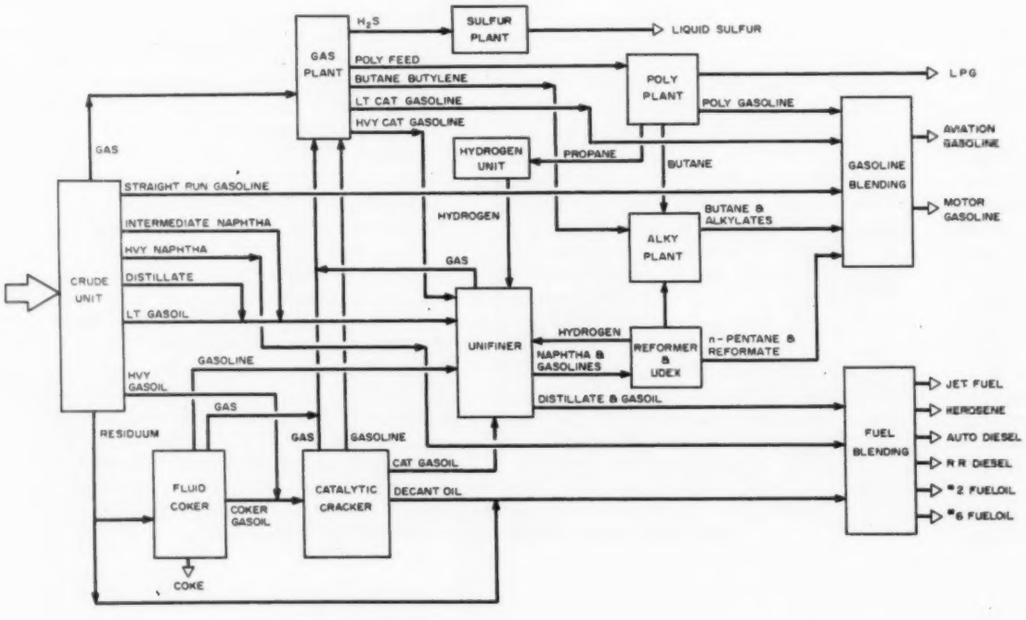
FLOW DIAGRAM
PETRECO DUAL-STAGE ELECTROFINING PROCESS

Panorama of Tidewater's new Delaware refinery: Main units (from left to right): power plant, fluid coker, sulfur plant, crude unit, cat cracker, gas plant, cat poly, alkylation, Udex, Houdriformer, Unifiner, hydrogen unit.

THE STORY BEHIND . . . TIDEWATER'S DELAWARE REFINERY

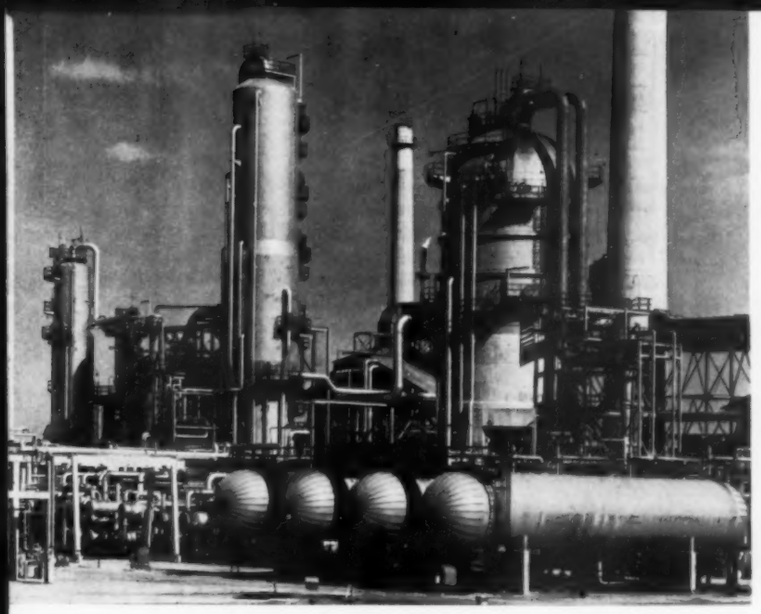
Four years of study, planning, and building lie behind the $200 million refinery centered on 5,200 acres of farmland in Delaware, more than 100 miles from the manufacturing site Tidewater has occupied for more than a half century. Engineering and management thinking on location, the 11 processes selected, and the sizing and integration of units is detailed.

by Thomas M. Anderson[1] and Howard M. Mathis[2]



Simplified flow diagram to indicate how process units are tied together for most efficient overall performance.

[1]Project manager.
[2]Senior chemical engineer.



Crude unit, with a design capacity of 130,000 b/d, has charged as high as 145,000 b/d. Unit is designed to process sour crude in three steps: prefractionator, atmospheric, and vacuum. The atmospheric column is 23 ft in diameter, and the 40-ft vacuum tower is the largest in the industry. The heaters are the first designed to burn fluid coke.

Cracker and gas plant are on the same plot for process-heat conservation. The M. W. Kellogg Orthoflow fluid cat cracker is designed for a raw charge of 58,000 b/d of gas oil and a total throughput of 102,000 b/sd. Coke-burning capacity is 58,000 lb per hour. The regenerator is 59 ft in diameter. The gas plant can handle 88 mmcf per day.

THE new Tidewater Delaware refinery is big. So big, in fact, that its sheer size has been the favorite topic of reporters up to now. But size alone is not the whole story. Of far more significance is the economics which underlies the planning and construction of the project.

Just how did the whole thing start? What made Tidewater decide to shut down an operating refinery and leave a community where it had been well established for many years? How did it choose the new plant site? What were the factors involved in selecting and sizing the process units in the new Delaware refinery?

Ventures like this one are not lightly undertaken. To understand the reasons behind such a far-reaching step, let's consider the trends of East Coast refining over the past several years.

The basic pattern of raw materials, refinery processes, and finished products has changed markedly since the end of World War II. Time was when East Coast refineries operated on domestic light sweet crudes almost altogether. This is no longer the case. The availability and price differential in favor of heavy sour crudes, both foreign and domestic, has caused a tremendous jump in their usage. To turn these low-grade crudes into high-quality products, the present-day refiner must have a plant which embodies the most carefully selected processes and the most suitable materials of construction.

Along with the changes in crudes, the refiner has been faced with a problem at the other end—his products. Not only is product quality steadily rising, but the amounts of the various refinery products must be continuously adjusted to meet the changing market conditions. The refiner can maintain his competitive position only by keeping his plant up-to-the-minute.

One other trend which has been apparent lately is the growing movement toward locating plants outside the highly populated metropolitan areas. No longer is it either necessary or economical to build an industrial plant in a city. Real-estate values, taxes, labor costs, employee satisfaction—all point toward the rural or suburban areas as the ideal present-day plant sites.

So much for general trends. Now, how did these factors affect Tidewater's Bayonne refinery specifically?

The Bayonne refinery has been in operation for more than 60 years—one of the nation's oldest refineries. Shortly after the end of World War II, Tidewater, like other refineries, felt the need of modernizing the plant to meet changing demands. Some relatively minor changes and additions were made to upgrade finished products. But the refinery was basically unsuited for processing sour crudes.

By 1953, Tidewater concluded that a major revamp would be necessary to maintain or improve the company's position in the eastern market. The time had come to take advantage of outside experience to help decide a future course of action. Accordingly C. F. Braun & Co. was commissioned to work with Tidewater's eastern division on a thorough study of its operations.

Tidewater and Braun engineers spent considerable time in the Bayonne refinery and in Tidewater's New York offices gathering information on marketing, refining, facilities, operating costs, maintenance costs, and crude supplies. Then they analyzed the accumulated facts and figures in the light of the general East Coast refining activity, market and product-quality trends, and made profitability studies on a variety of processing schemes.

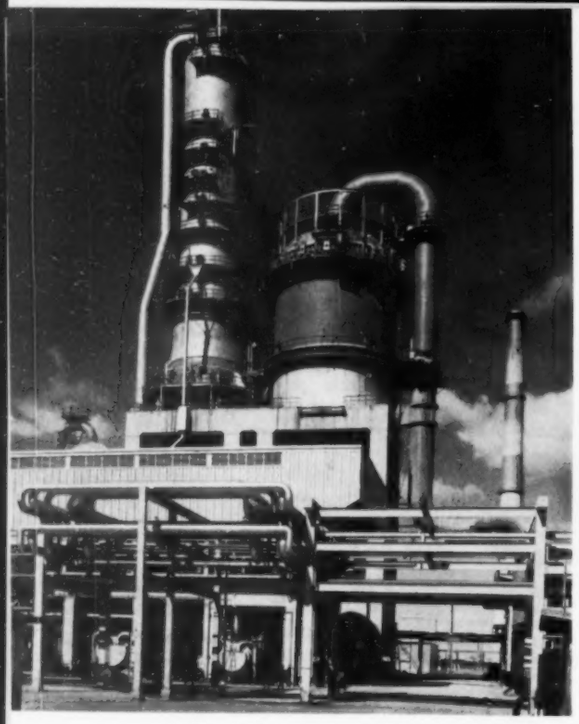
All the general trends indicated that basic changes to the refinery process units would be required to bring Tidewater's East Coast refining facilities up to date. But a detailed and comprehensive economic study was needed to determine just what changes should be made and whether they should be made at Bayonne or somewhere else.

The Bayonne refinery, as was the case with most older refineries, had grown like Topsy, in a natural bulging fashion. Many of the process units were worn out or nearly so resulting in sky-high maintenance costs. None of the units was suitable for processing sour crudes. Most were of small capacity, resulting in duplication of units and high operating labor costs. The supporting utility systems and general facilities were obsolete and inadequate. A sizeable part of the plant investment was in lube facilities, but lube products had become a smaller-volume lesser-profit part of the business. Construction of several new processing units was clearly indicated.

In considering plant location, engineers could find nothing but inertia which favored staying in Bayonne. The property was not suited for economic layout of the new facilities, and it was not adequate for future expansion. The waterfront facilities would not accommodate the large tankers which were coming into crude and product service. Labor rates in the area were high, and going higher. Local taxes were excessive. With these drawbacks, the prospect of modernizing the Bayonne plant was not attractive.

A painstaking analysis of all the relevant factors showed that continued operation of the Bayonne refinery was not economically sound. Many concurrent events had created an unusual situation. On the basis of dollars and cents, the decision was clear-cut—abandon Bayonne and build elsewhere.

As part of their studies, Tidewater and Braun engineers recommended that the new refinery be built in the Delaware valley. Sites were available outside of cities, and accessible to the largest tankers. Labor was available at reasonable rates. The location was central with respect to



The fluid coker is the largest yet built. It will charge 42,000 b/d of reduced crude to produce 1,500 tons per day of coke. A CO_2 boiler will aid in heat conservation. Coke will be burned at the adjacent plant of Delaware Power & Light Co. and in the Tidewater crude heaters.

Tidewater's marketing area. And the valley had a record of generally good labor relations. The specific plant site was selected only after exhaustive investigation of all pertinent factors, including soil conditions.

Once the decision had been made to build from the ground up, the engineering of the new plant forged ahead rapidly. Braun was given a contract for the overall engineering coordination, design, and construction. The premises established by Tidewater were simple. The refinery was to be designed to produce the highest quality products from low-grade crudes. It was to be the most efficient and flexible plant possible, consistent with safety and economy. It was, in short, to be the world's most modern refinery.

Throughout the entire engineering phase, the program was tremendously benefitted by th absence of preconceived ideas or narrow-channel thinking. There were no sacred cows. The selection of processes was based on economic studies. The sizing of the process units, and the decisions between single or multiple units—these, too, were based on dollars-and-cents comparisons. The process engineering, choice of equipment, unit layouts, and similar engineering problems were left to Braun, subject only to review and approval by Tidewater's engineers. The result was a coordinated effort which brought outstanding results from start to finish.

The economic studies had shown not only that it was possible to refine sour crudes economically, but also that the heavy sour crudes offered the larger profit margin. This premise established the refining plan. The latest developments in refining processes were carefully evaluated. The chosen few were those which gave the greatest dollar return on the investment, after crude costs and operating costs had been deducted from product realization—all without limitation to specific types of crude.

Once the overall refinery throughput had been established, the problem still remained of integrating the capacities of the various processes. This problem demanded careful study of a vast number of factors —available crudes, product distribution, transportation and storage facilities, power and steam balances, planned turnaround schedules, and many others. Each process had to have sufficient capacity to keep pace with other units during extreme operating cases. Yet sound economics dictated that the unit capacities not be greater than necessary. The proper selection of storage and handling facilities for intermediate products went hand in hand with the sizing of the process facilities.

Next came the economic balance between capital costs and operating expense. The first impression given by the Delaware refinery is the huge size of the individual one-of-a-kind process units. But far more than "pride in the largest" dictated the selection of those units. Duplicate, smaller units would have required higher investment, duplicate operating and maintenance crews, and other additional expense. True, the single, large units involved some additional costs to provide the necessary built-in reliability. While this reduced some of the expected savings still the duplicate-unit route would have substantially increased capital costs. With the steady increase in labor rates, the added operating labor made duplicate units even less attractive. All economics pointed clearly to large, single units with built-in reliability.

Obsolescence is a constant threat in refining where product quality has climbed continuously through the years. While today's products give a factual basis for process selection, a unit built today must be designed with an eye to meeting the increasing quality requirements of the years ahead. This prerequisite for a long, useful life was incorporated into the premises for process selection.

The Delaware refinery is the result of the application of these fundamental premises. Th process units were chosen for best economics and sized for lowest operating and maintenance costs. The supporting facilities were selected and designed to serve the process units most efficiently. The latest developments in instrumentation, gauging, and automatic logging were put ot use. The end result is the world's most electronically controlled refinery.

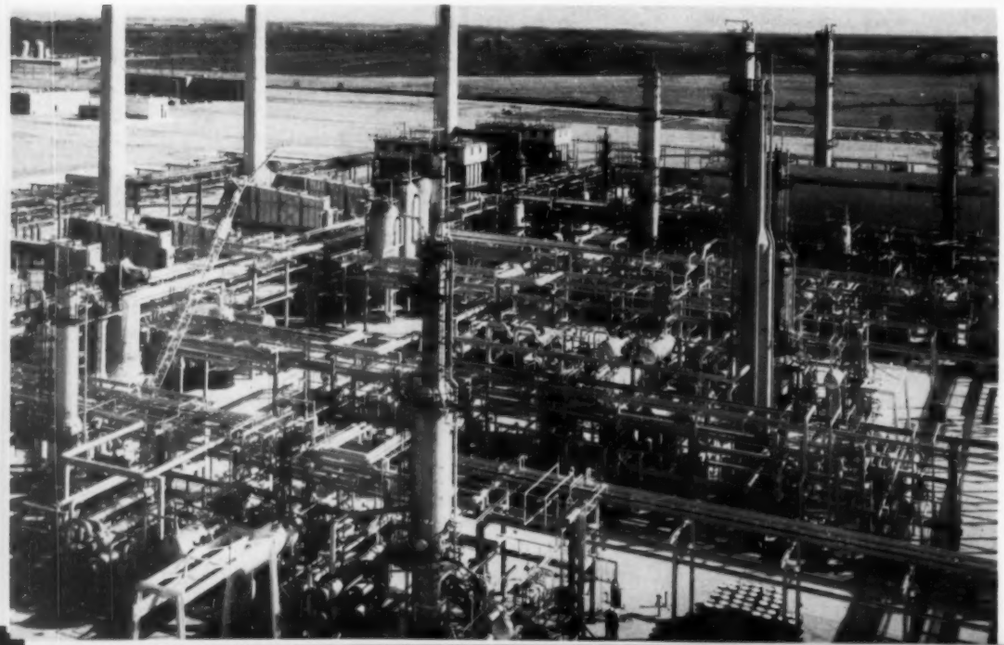
The 11 process units include nine licensed processes, four of them designed by the licensors. Design of all the others, procurement of all equipment and materials, and all construction were by Braun.

The first step in processing crude is the separation of its various fractions. For this, the largest crude unit in the world was designed and erected. It is capable of running 130,000 b/d of light or heavy crude or crude blends. Electrical-precipitation desalters remove the water and mineral salts from this entire charge. Light-gasoline fractions are final-treated and stabilized on the same plot. They leave as finished blending stock. The atmospheric crude tower separates the heavy gasoline and middle distillates into appropriate fractions for reforming, finishing, and blending. The 40-ft-diameter vacuum tower strips the heavy gas oil for reprocessing by the catalytic-cracker. Only metallic components and asphalt are left in the heavy black-oil bottoms.

The two liquid products of the vacuum column go, one to the cracker and one to the coker. The huge Orthoflow fluid catalytic cracker has a design capacity for 102,000 b/d total feed. Here the heavy gas oil is catalytically broken down into gasoline and No. 2, or domestic-type, fuel oil. This is the first big conversion of heavy low-value fractions into high-realization products. What is more, the cracker does a nice job of sulfur removal but, with high-sulfur crudes, not enough.

The heavy residuum, or bottom of the

Unifiner and hydrogen plant: Individual trains are separated by maintenance access ways equipped with track-mounted lifting equipment. Provision is made to produce up to 30 mmcf per day of hydrogen from propane to supplement supplies from the Houdriformer. Hydrogen will be used to desulfurize five refinery streams.



barrel, has long been the blight in refinery economics. As produced, there was no market for it. It could be visbroken and made somewhat less offensive. But it always required blending-in of a sizeable amount of higher-value middle distillate to make it salable even as bunker fuel. The recent development of fluid coking afforded an attractive tool for the conversion of this least desirable material into high-value gasoline and middle distillates.

The fluid coker in the Delaware refinery and its sister at Tidewater's Avon refinery are the largest in the world. Each is capable of charging 42,000 b/d of heavy residuum. The coker makes gasoline, light gas oil, heavy as-oil feed for the cat-cracker, and a small yield of fluid coke—a conveniently handled marketable, solid fuel. It is this unit which puts an end to the refineries' heavy-residuum problems and permits the economic refining of the low-gravity crudes.

In the past, the finishing of various-blending stocks was accomplished by chemical treatment. This was costly; and, where heavy treating was required, it was detrimental to yields. Little sulfur could be removed economically. The recently developed use of hydrogen for stabilization and desulfurization is, therefore, a key process in refining high-sulfur crudes. The Delaware refinery has an 88,000 b/d 5-train hydrodesulfurizer or Unifiner, which uses reformer hydrogen and hydrogen from the hydrogen unit to finish middle distillates from the crude unit, cracker, and coker for final blends. It also cleans up the heavy gasoline for catalytic reforming. In the hydrogen unit, propane is steam-reformed into hydrogen to make up shortages in reformer hydrogen when running very sour and heavy crudes.

The march of octane numbers and the stagnation of kerosine sales has left large volumes of heavy low-octane gasolines without a market. Catalytic reforming is the answer to this problem. In the Delaware refinery, the 45,000 b/d Houdriformer lifts the low-octane to high-octane fractions. The Udex unit takes the products of the reformer and separates the aromatic fractions for the tailor-made gasoline of the future.

The story of the liquid products does not end here. Valuable light ends are produced in each processing and finishing operation. These are collected and processed in a single gas plant. This plant recovers 85% of the propane-propylene and all heavier fractions. It splits and treats the cat-cracked gasoline for sulfur control.

The propane-butane fractions from the gas plant supply the feeds for the polymerization and alkylation plants. These two related operations reduce the condensible fractions of these gases to high-octane liquids. In two integrated steps they give the refinery both maximum liquid-recovery and vapor-pressure balance. Aviation alkylate from the alkylation plant is the prime base stock for the refinery's aviation-gasoline production.

Sulfur removed during hydrodesulfurization and catalytic cracking comes off as hydrogen-sulfide gas. The toxicity of this gas, and the odors connected with it, have been a serious problem to refiners. By selective absorption, the H_2S is removed from the waste gases. The high-purity acid gas goes to the sulfur plant. Here, by partial oxidation, it is converted to liquid sulfur. At maximum capacity, the Delaware refinery is equipped to remove and produce some 375 tons a day of molten sulfur. Here an undesirable waste product is turned into a source of income.

Removal of sulfur was only part of Tidewater's good-neighbor policy. The refinery is built to meet strict requirements such as are set up by the Los Angeles Air Pollution Control District, said to be the most exacting in the country. The waste gases are dispersed some 300 ft. in the air, and the liquid effluents are treated in an extensive system so that the water returned to the Delaware River is as clean as the intake water.

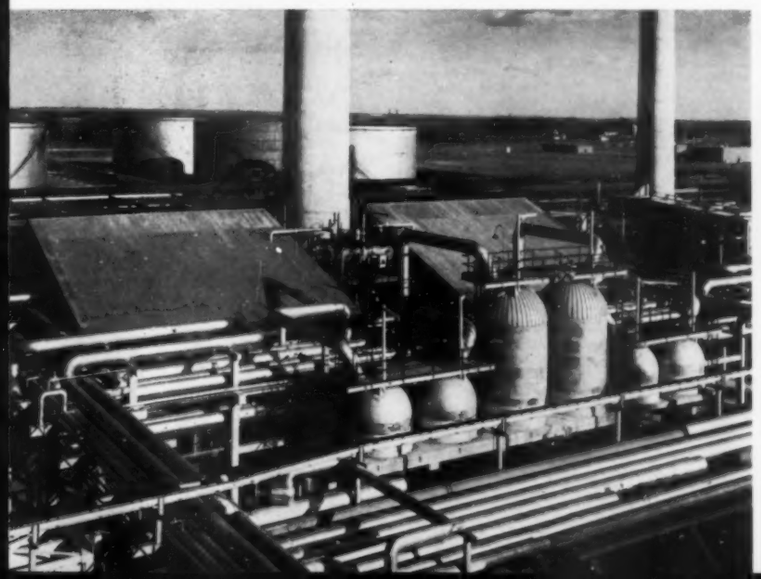
The problem of plant layout was a real challenge. But, equally important, it was a unique opportunity. With essentially unlimited territory available, there were practically no restrictions on planning the layout for the most efficient construction, operation, and maintenance. At the same time, provisions could be, and were built in to assure that expansion would be logical and economical. Process units general facilities, and storage areas were located for the most efficient flow of products throughout the refinery—always with an eye to future needs.

The layout of each individual unit was the subject of equally careful study. Two factors were uppermost in the planning—convenience of operation and ease of maintenance. Here Braun's consulting experience in reducing maintenance costs in some 35 refineries and industrial plants paid off handsomely.

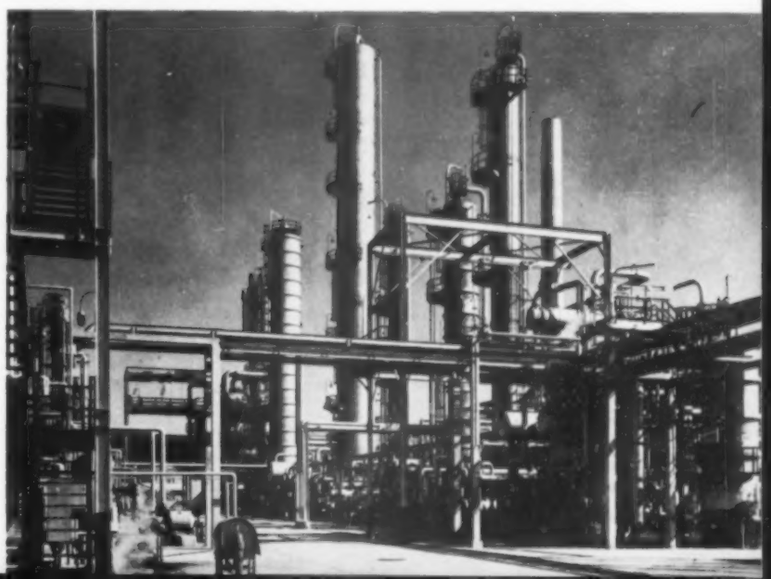
The blending of finished base stocks into final products is a continuous in-line process, largely automatic in operation. In comparison with the older batch-blending methods, the continuous process is faster; it reduces the inventory of stocks in process; and it allows better control over product composition. The design provides for flexible operation to meet present and anticipated needs. The extensive use of automatic controls improves reliability and minimizes manpower requirements.

There are three blending units—one for gasoline, one for No. 2 fuel oil, and one for other distillates such as kerosine, diesel fuels, and jet fuel. The blending rates and percentages are set from graphic panels located in a central control house. The blenders meter and control from three to seven components to produce the finished blended products. When blending starts, the flow of each component is automatically corrected for gravity, integrated, and shown in a batch counter. The total product flow is continuously displayed on a strip-chart recorder, in addition to being integrated and shown on batch and cumulative

The twin-train Houdriformer has a charging capacity of 45,200 b/d, the largest yet built. A Udex unit was installed to remove aromatics from the Houdriformer product and return 15,000 b/d of recycle stock for further reforming. Each heater is rated at 156 million Btu per hour.



The M. W. Kellogg sulfuric-acid alkylation unit is designed to produce 5,000 b/d of aviation-grade alkylate. Minor changes can be made to produce larger volumes of motor-fuel alkylate. The gas plant supplies 7,500 b/d B-B charge, and the Houdriformer 2,900 b/d of stock containing needed isomers.



counters. The total blending rate can be changed at any time to meet production requirements without disturbing the percentage settings for the components. The batch counter can be preset to automatically stop the blending operation when the desired amount of product has been made.

Numerous safeguards insure continuous product quality. Each component measuring system is checked in recycle operation before actual blending is started. During blending, the bow of each component and the rate of tetraethyl-lead addition are continuously and automatically compared with the values set on the master controller. Any deviation beyond preset limits automatically stops the entire blending operation.

Crude oil for the Delaware refinery, and a major part of the refinery's products, pass through the marine terminal. Three large *T*-head piers are equipped to serve vessels ranging from river barges up to 50,000-ton supertankers of the Tidewater ocean fleet. Situated on the west bank of the Delaware River, just north of Delaware City, the terminal is about two miles due east of the refinery process area. It was located to give the shortest possible pipelines to the tankage area, and at the same time to be as close as possible to the main river channel for the least dredging.

As a part of the engineering study for the water-terminal design, the good and bad features of 10 modern refinery docks were analyzed. One important result of the study was the development of new structures and equipment for hose-handling which require only two men to connect or disconnect the heavy loading hoses. The hoses on each pier are supported in a 68-ft-high steel tower topped by a 40-ft boom operated by three air winches. Up to 11 hoses are racked in each tower, with each 75-ft hose individually controlled to position the end of the hose at the ship's nozzle. A push-button station on each pier operates the hose winches and the loading pumps.

Four separate water systems are required to satisfy the needs of the 130,000 b/d refinery and the adjacent 50,000-kw power plant, which Braun built at the same time for Delaware Power and Light Co. One system supplies river water for cooling. The other three systems supply drinking water, raw water, and treater water, from deep wells. Of the four, the cooling-water system is of especial interest because of the unusual provisions made to assure an unfailing supply along with operating flexibility, and economy of first cost and operation. The use of brackish water, the quantity of cooling water, and the soil conditions, all introduced unusual problems in design and construction. Salinity of the Delaware River is sometimes as high as 25,000 ppm—almost equal to that of sea water. The 275,000 gal per min of cooling water used by the refinery and the power plant is equivalent to the water consumption of a metropolitan area such as Greater Philadelphia.

This cooling-water system is a key factor in the operation of the entire refinery. Since practically all of the refining processes are continuous, a failure of water supply would cause an immediate shutdown of part, or possibly all, of the refinery. The resulting loss of production would be very costly. Thus, special steps were taken to make the system reliable, flexible, and durable.

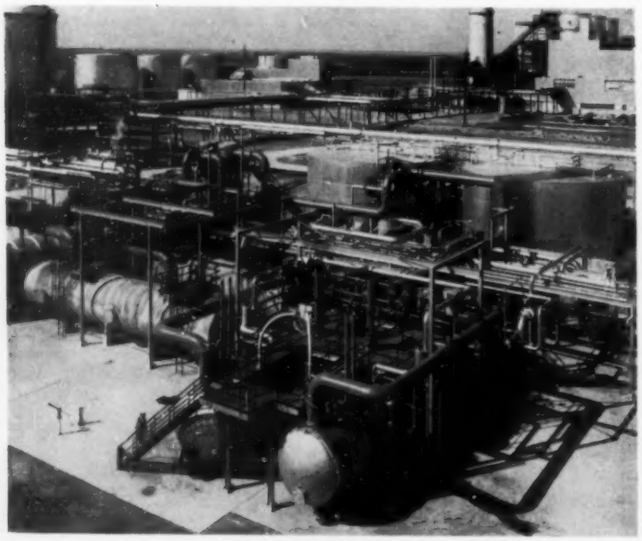
A high degree of reliability is built into the system by the careful selection of equipment, by paralleling conduits and certain equipment, and by providing spares for the most essential equipment. Vital equipment can be maintained and repaired without a complete shutdown. All parts of the system—except the inlet channel, the outlet channel, and the separator—are built in multiple. Continuity of power to the pumps is assured by two sources of electric power and by the use of dual feeders to the two substations.

Flexibility of operation, particularly during the start-up and shutdown of process units, was a prerequisite. Based on the planned turnaround schedule, demand for cooling water may vary from as little as 140,000 gpm up to the 275,000 gpm design figure. The use of nine pumps, dual headers, dual return lines, three guard basins, and properly located valves provide for practically every eventuality.

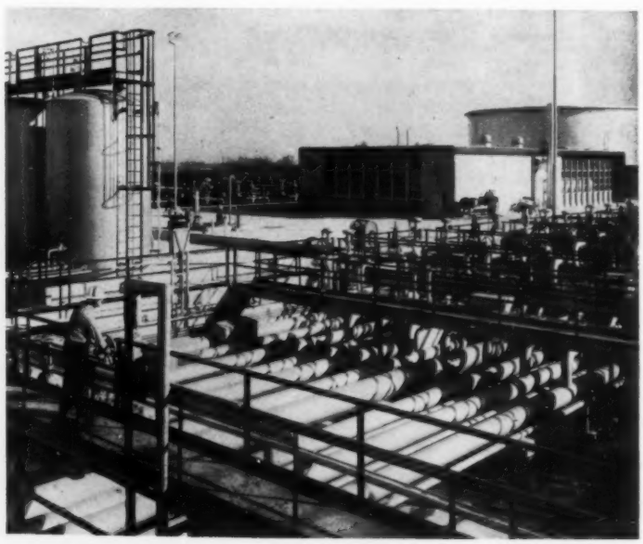
The river water of high salinity called for particular attention to the durability of the system. Alloys protect against corrosion of the screens, pump parts, strainers, in all of the heat exchange equipment, and elsewhere. Steel pipe is lined with concrete. Surge tanks and check valves protect against water-hammer. The lining of open channels protects against hydraulic scour.

Modern instrumentation plays an important part in the design and operation of the refinery. Early discussions between Tidewater and Braun engineers formed a basis for the selection and application of instruments throughout the refinery. Uniformity of instrument types and application reduced the problems of engineering, purchasing, installation, commissioning, and maintenance.

The newest techinques in process instrumentation have been built into each control house. Two major assemblies, viz., a control board and an information system, form the heart of the instrumentation. Process control is centralized on the control boards. Graphic panels are provided for all re-



The sulfur-recovery plant is another "largest," with a capacity of 340 long tons of sulfur per day. Licensing and processing were Ralph M. Parsons Co.; procurement and construction, by Braun.



Three automatic in-line blenders handle all distillates automatically. The motor-fuel section blends seven components to market specifications at 10,000 bbl per hour; the No. 2 fuel system, five components; and the kerosine, diesel, and jet-fuel section, three components.

finery processing units. All board-mounted instruments are miniature pneumatic receivers.

The information systems give a continuous and automatic up-to-the-minute picture of unit operation. An information system includes a scanner, a digital indicator, a trend recorder, a logging typewriter, and a tape punch. The scanners are connected to the measuring elements throughout the process. These information systems represent the largest installation of their kind in the process industries. There are a total of 13 systems—one for each process unit, plus a special logger-computer for the tank farm. Capacity is provided for 4,700 points total.

The decision to install the information systems was based mainly on economics. They pay out in two to three years by (1) reducing the cost of the board-mounted instruments and the size of the control houses, and (2) by saving the cost of manual logging and the clerical work associated with manual accounting methods. Averaging, totalizing, and summarizing become automatic—from the point of measurement to the final report.

Building the Tidewater refinery, complete with its general facilities units and power station, stands as the largest such construction project in the history of the petroleum processing industry. Five hundred engineers and coordinators teamed up with 10,000 craftsmen to build the job.

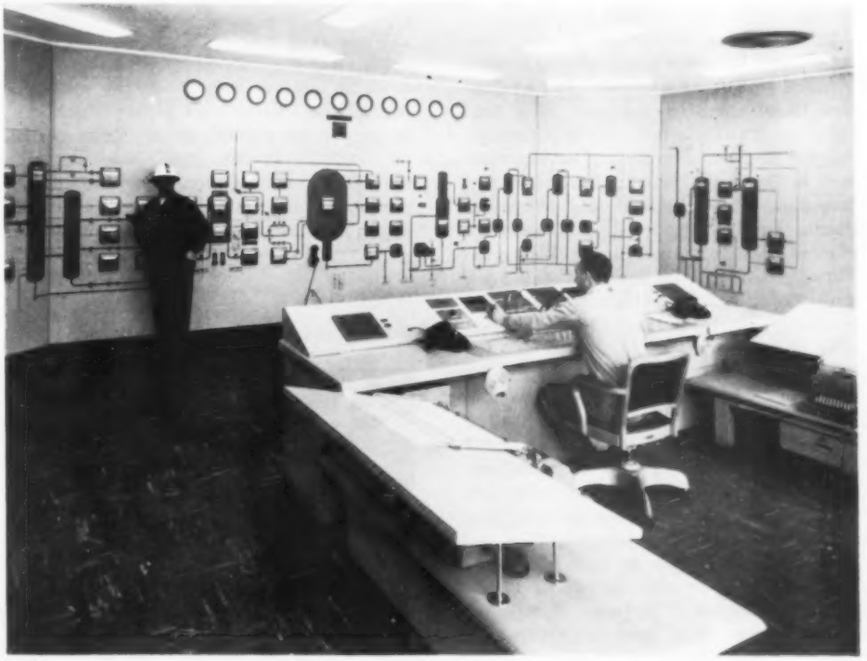
They moved 16 million cubic yards of earth, placed 132,000 cubic yards of concrete, and erected 9,000 tons of structural steel. They installed miles of railroad spurs and roads, a marine terminal for supertankers, and a 275,000-gpm water system. Yet these were but the trimmings, secondary to the business end of the refinery—the 11 large process units. In these units, erection crews set 1,500 pieces of major equipment; electricians strung 400 miles of wire; and pipefitters installed close to 1,000 miles of pipe of all sizes, requiring myriads of fittings along with 100,000 valves ranging up to 8 ft in diameter.

The manpower pool in any big industrial area would feel a severe strain when required to supply 10,000 men of more than 25 different crafts to a single job site. The Delaware valley was no exception. Personnel recruiters drew craftsmen from far and wide to meet their manpower quotas. In tight spots, Braun adopted such unusual measures as the operation of a welding school at the job site, where some 400 pipe welders were trained during the project.

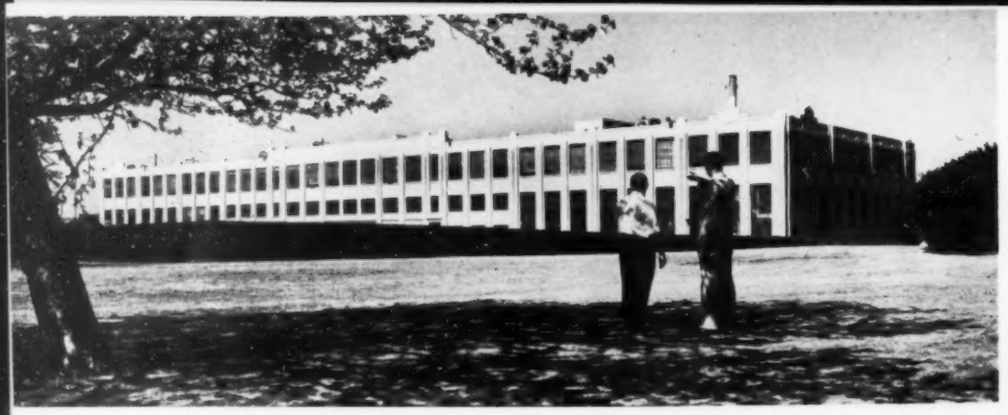
The magnitude of the project created problems never before encountered in refinery construction. The successful solution of these problems is a tribute to teamwork of a high order—teamwork between owners, engineers, construction staffs, subcontractors, and craft unions. All who participated can be proud of their part in building Delaware's new landmark and the world's most modern petroleum processing plant—The Tidewater Delaware Refinery.

END

The Delaware River terminal two miles from the plant, with three piers, can accommodate vessels up to 68,000 dwt. Berths are dredged to 40 ft. Hose up to 10-in. is handled by one man from 68-ft hoist towers handling up to eleven 75-ft hoses. The 30-in. crude line to the refinery can handle 25,000 bbl per hour.



Nine process-unit control rooms are equipped with graphic charts and automatic information systems. High-speed scanning, data reduction, and logging keep a continuous check on conditions at thousands of points in the various units, and warn the operator of abnormal pressures, temperatures, or rates of flow. Pannelit installed the system and maintains it.



New Lummus engineering development building at Newark, N.J.

Lummus enlarges engineering development service facilities

THE Lummus Co. has enlarged its engineering development service to oil refining and petrochemical industries through the purchase of a 150,000-sq-ft building at Newark, N. J. The new center, with spacious grounds for outdoor work or future expansion, replaces the smaller quarters at Bayonne where Lummus has carried on this type of work since 1930.

At this center, as well as at the older installation, Lummus restricts its activities to process plant development and evaluation. Basic chemical research is a field which is left entirely to Lummus customers.

In the previous engineering development work at Bayonne, Lummus has found that almost any new chemical and petroleum process can be considered as a series of relatively simple units. This approach permits concentration on one part of the job at a time. And it also permits translation of previous experience and technology on many of the same types of process building blocks.

Typical unit operations, integral in all the complex plants built today, include heating and cooling, distillation, fractionation, contacting, filtration, and solvent extraction. Unit processes include oxidation, reduction, catalytic cracking, esterification, hydrogenation, and polymerization.

These same schematic building blocks are used, with only slight variations, in all process industries. They may even have different names when used to produce different end products.

In the new Lummus center, the company has a large stock of columns, vessels, and other process elements which can be readily assembled into pilot plants. Where elements are not in stock, the machine shop is prepared to fabricate them to specification. In many cases pilot-plant investigative work enables engineers to scale up commercial plants on ratios as high as 10,000 to 1. Commercial results sometimes may be predicted within 0.01% from pilot runs. At other times research and experience have shown that intermediate development in semi-commercial scale units must be done.

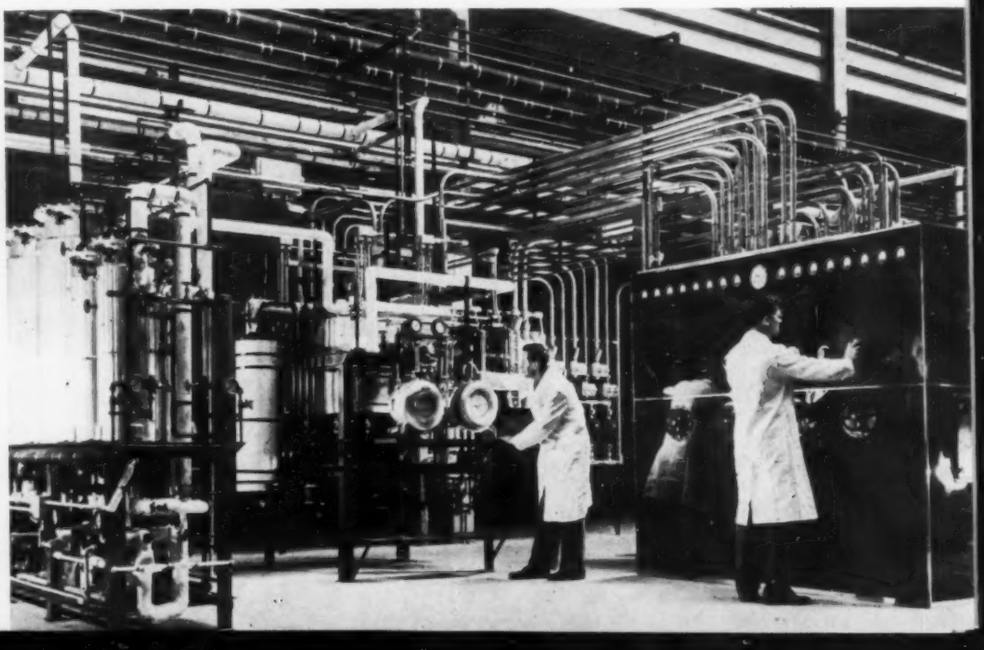
While runs may be made at Newark in small units charging samples as small as 1 cc or as large as a tank car, the company may create mobile pilot plants which can be sent to the refinery for continuous runs on available streams. One such Lummus unit is a trailer-mounted pilot plant for producing olefins direct from available stocks at refineries and chemical plants.

The new Lummus engineering development center was built originally as a manufacturing plant. It has a large central area served by cranes for moving and setting up heavy pilot-plant units. Other bays are available for the segregation of specialized work where safely-controlled conditions may be required.

Testing bays are served by 300 psi steam, water, vacuum, nitrogen, ammonia liquid, and vapor return; 150 psi compressed air, city gas, and electric power. CO_2 and sprinkler fire protection is provided. All electrical wiring and apparatus are designed for operation in hazardous service.

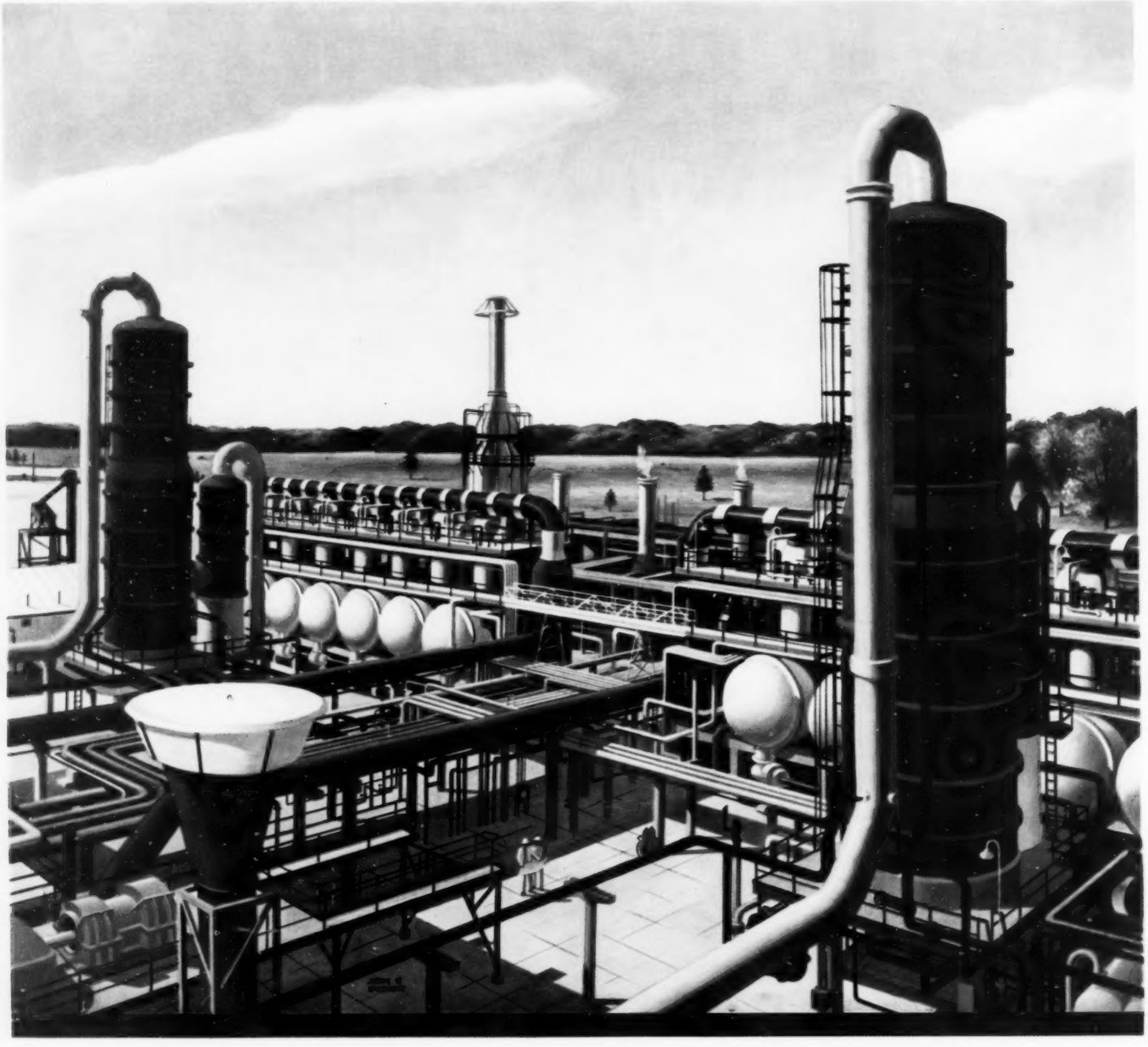
The new engineering development center is located only 30 minutes from the center of the city of New York. END

Typical pilot-plant setup employed to study refinery and petrochemical process steps.



PROTECTION

SCHLUMBERGER
THE OIL MAN'S
PROTECTION



TEXAS BUTADIENE & CHEMICAL CORPORATION

The new Houston plant of Texas Butadiene & Chemical Corporation is now on stream with two 43,000 ton-per-year Houdry Dehydrogenation Units. In a single-step process, these two units transform butane feed into desired proportions of butadiene and butenes. They can provide 65,000 tons of butadiene and enough butenes for 2.5 million barrels of light alkylate. Or, by recycling butenes, it is possible to produce up to 86,000 tons-per-year of butadiene alone. This process employs a Houdry Chrome-Alumina Catalyst which in exhaustive tests has demonstrated its selectivity, ruggedness, and stability.

For information about Houdry Processes and Catalysts, write to: Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pa.

HOUDRY
PROCESS CORPORATION
Pioneer in Catalytic Processes

As a result of the rapid growth in capacity during the past six years, 80% of Commonwealth demands for oil products now can be met by

EXPANDED AUSTRALIAN REFINERIES

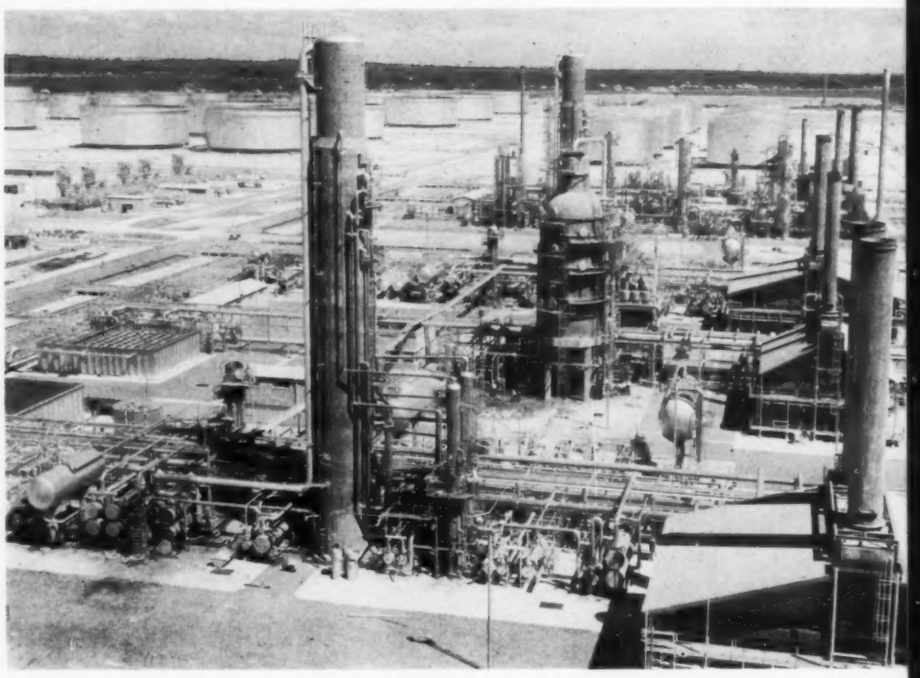
by D. M. Pilcher, Director,
Petroleum Information Bureau (Australia)

FOUR international oil groups embarked on a great program of refinery construction in Australia about six years ago. With the coming onstream, in February last year, of the last of a chain of new modern refineries at Kurnell, near Sydney, New South Wales, Australia is now in the satisfactory position of being able to refine about 80% of its total petroleum requirements.

Four modern refineries have been erected at strategic points on the Australian coastline, at a total cost of about £115 million Australian ($258 million). The Shell refinery at Geelong, 40 miles from Melbourne, Victoria, was begun in mid-1951, and was the first to come onstream in March 1954. Within two more years, British Petroleum's refinery at Kwinana, near Fremantle, Western Australia; Standard-Vacuum refinery at Altona, 10 miles from Melbourne; and Australian Oil Refining's plant at Kurnell, 25 miles from Sydney, New South Wales, were all in operation.

Australia is now refining about 85% of its requirements of motor spirit. It began manufacturing aviation gasoline in March last year; current production is now approaching 50% of the local market. The country is self-sufficient in capacity to refine its needs of distillate, diesel and fuel oils; and there is, in addition, a surplus of these products for export.

In the next few years Australian refineries are likely to work gradually towards meeting all domestic requirements of motor spirit, but the extent to which they do this depends largely upon the in-



Shell Refining (Australia) Pty. Ltd. plant at Geelong, 40 miles from Melbourne, has a capacity of 2,200,000 tons of crude per year. The refinery has atmospheric and vacuum distillation, catalytic cracking, polymerization, Platforming, and ancillary units.

◀ *BP refinery (Kwinana) Ltd.: Oil processing units with the tank farm in the background.*

centive given by way of tariff protection.

The decision to embark on large-scale refinery construction in Australia was taken by the four overseas groups in pursuance of the new policy developed during and after the war which made it highly advantageous to have refineries situated at the point of consumption of the refined product rather than at the point of recovery of the crude from the earth. Australia was recognized as a desirable place for the establishment of refineries because of its rapid economic development, accompanied by conditions of political stability.

The four groups which have established new refineries in Australia since 1951 are.

The British Petroleum Co. Ltd., operating through BP Refinery (Kwinana) Ltd., at Kwinana, on Cockburn Sound, near Fremantle, Western Australia. Cost £40 million.

The Shell Co., operating through Shell Refining (Australia) Pty. Ltd., on Corio Bay, near the port of Geelong, Victoria. Cost £28 million.

The Standard-Vacuum Oil Co., operating through the Standard-Vacuum Refining Co. (Australia) Pty. Ltd., at Altona, a suburb of Melbourne, adjoining the port of Williamstown, Victoria. Cost £22 million.

Australian Oil Refining Pty. Ltd., operating on the historic Kurnell Peninsula, Botany Bay, New South Wales. Cost £25 million.

In addition to these new refineries, the Shell Co., has a plant with a current capacity of 500,000 tons of crude per year at Clyde, NSW; while Bitumen and Oil Refineries (Australia) Ltd., in which the California Texas Corp. is interested, has plants at Matraville, NSW, and at Hamilton, Queensland, the combined capacities of which amount to about 600,000 tons a year. The Clyde refinery is being expanded by the addition of a Platformer and extension of the crude-distillation unit, which are designed to lift capacity to 800,000 tons a year early in 1958.

The current capacity of all Australian refineries amounts to approximately 9,300,000 tons of crude per annum (186,000 b/d), divided as follows:

	Tons
BP Kwinana, WA	3,000,000
Shell, Geelong, Victoria	2,200,000
Standard-Vacuum, Altona, Victoria	1,500,000
Australian Oil Refining, Kurnell, NSW	1,500,000
Shell, Clyde, NSW	500,000
Boral Matraville, NSW Hamilton, Queensland	600,000
Total	9,300,000

The impact on the Australian economy of the great construction program involved in the erection of the new refineries was tremendous. Their erection led directly to the creation of great spending power in Australia, which in its turn led not only to the employment of large numbers of people engaged in the actual building, but to a demand for all manner of specialized engineering and electrical equipment which was responsible for the expansion of many existing industries and in some cases the establishment of new ones.

The building of the Kwinana refinery was the largest single commercial project ever undertaken in Western Australia. The state government offered power and water supplies as special incentives to building on the Cockburn Sound site, and cooperated in the establishment of the model township of Medina, which houses employees operating the plant.

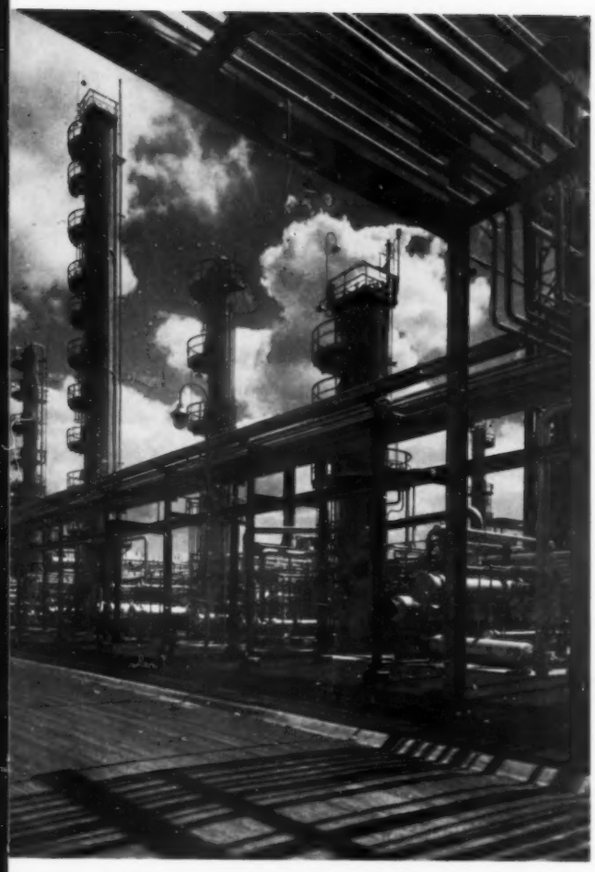
At Geelong and Altona, in Victoria, the towering edifices of aluminum-coated pipes have become familiar landmarks on the skyline. They are impressive examples of new additions to the nation's industrial equipment which have come into being almost overnight. The Shell refinery at Geelong is connected with its metropolitan distribution depot at Newport, 36 miles away, by the longest petroleum pipeline in Australia.

Standard-Vacuum's Altona refinery is the only one at present producing aviation spirit in this country.

At Kurnell, on historic Botany Bay, New South Wales, where Captain Cook first set

TABLE I

	Refinery Production 1956	Australian Consumption 1956
	(Thousands of Gallons)	
Aviation spirit	10,024	45,543
Motor spirit	734,173	941,131
Aviation turbine fuel	20,269	21,760
and lighting kerosine		58,494
Power kerosine	5,570	67,477
Automotive diesel oil	145,819	142,798
Industrial diesel oil	276,129	227,096
Fuel oil	661,739	582,889
Lubricating oil	8,618	51,936
Bitumen	44,196	41,800



Alkylation unit at Standard Vacuum's refinery at Altona, Victoria, 10 miles from Melbourne, which is designed to produce 50% of Australia's aviation-gasoline needs.

Standing on sandy waste country where Captain James Cook first set foot on Australia in 1770 is Australia's newest refinery. Operated by Australian Oil Refining Pty. Ltd., the Kurnell plant—which came onstream in February 1956—has an annual capacity of 1,500,000 tons. The fluid cracking unit tower is shown between a row of giant tanks in the storage tank farm.

foot in Australia in 1770, sandy wastes have given place to Australian Oil Refining's new plant. The refinery is a familiar sight to air travelers approaching Sydney airport.

Completion of Australia's chain of modern oil refineries is graphic evidence of the country's rapidly growing industrial strength. Their erection is probably the greatest single leap forward in the industrial history of Australia. Their benefit to the economy does not entirely arise from the direct employment which they give. Oil refineries are, in fact, relatively small employers of labor, once the initial task of construction is completed; but the presence on Australian soil of widely dispersed plants, capable of refining virtually all the country's needs of petroleum products, is an asset the value of which is almost impossible to assess.

What difference, it might be asked, does it make whether the country's oil requirements are refined in Australia or elsewhere? The short answer is that the economic and strategic benefits deriving from the ability of a country to refine its petroleum products on its own territory make it unthinkable that any other pattern should be followed. It is true that war could conceivably cut off supplies of crude oil temporarily, but temporary interruption to supplies would be a relatively minor incident compared with a destruction, or even a shutdown, of an overseas refinery, upon which Australia depended.

The economic benefits to Australia of the establishment of a large-scale refining industry are even more apparent than the strategic benefits, although by no means more important. Apart from the fillip given to industrial expansion by the erection of four new refineries, there is an immediate saving in foreign exchange on imported petroleum products to the extent of the cost of refining the crude. This arises from the fact that practically all costs of refining are paid in Australian currency to Australians instead of to people in countries overseas.

The operations of the four new refineries, it is estimated, will enable Australia to save about £A25 million a year in foreign exchange necesssary to obtain imported petroleum products. In 1955-56 imports of petroleum were valued at £A90,900,000 equal to 11% of total imports of £821,042,000. Operations of the older refineries were saving Australia about £A3 million a year in foreign exchange, making the total savings £A28 million a year when all refineries are operating at full capacity. Of this estimated saving in foreign exchange, the dollar content involved could well amount to £A5 million ($11,200,000), a not insignificant figure in a time of dollar scarcity.

The exchange position will be further assisted as the refineries increase their production sufficiently to permit exports to nearby overseas markets. The value of having adequate refining capacity in this part of the world was demonstrated with the

(Continued on page 130)

Ethyl research takes a new approach to match future fuels and engines

By H. J. GIBSON, Technical Director, Ethyl Corporation Research Laboratories

COMBUSTION characteristics of future gasolines in tomorrow's engines have been defined in an extensive study recently completed in the Detroit Research Laboratories of Ethyl Corporation. This project pursued these two basic objectives.

First, to find out how variations in hydrocarbon composition, sensitivity and other characteristics would affect the ability of gasolines to meet the fuel requirements of tomorrow's engines.

Second, to determine how future engines could be modified to permit effective use of the widest possible range of fuel characteristics.

Engine Adjustments Lower Octane Requirement

Three high-compression test engines were selected for their high volumetric efficiencies and because each represented a different philosophy of combustion-chamber design. Compression ratios were increased to 11-to-1, a ratio that can be expected in passenger car engines in the near future.

Each engine was completely calibrated on an engine dynamometer in order to assure realistic tailoring of the carburetion and ignition characteristics of the engine for the most effective use of commercial-type gasolines.

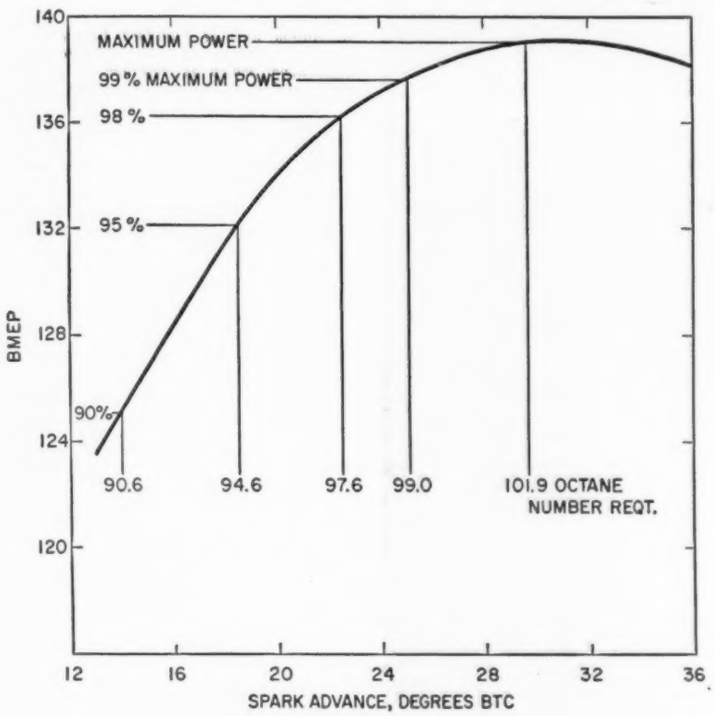
The engines were then installed in automobiles for road ratings of the fuels under test. Over one hundred commercial-type gasolines, including a wide variety of hydrocarbon compositions, were rated in these vehicles under carefully controlled conditions on a chassis dynamometer.

Results of the investigation indicate that a number of compromises can be made between engine performance and engine-fuel requirements.

For example, it was possible to lower the octane requirement with only nominal power loss and without significantly affecting fuel economy, by adopting slight modifications of spark advance and carburetor design.

It was further shown that it will be desirable for refiners to maximize the paraffinic and aromatic contents of their fuels in order to attain satisfactory operation at high engine speeds.

Low-cost olefinic blending components will continue to be effective in meeting the Research-octane-number specification required to satisfy the engine at low speeds.



This graph illustrates the relation between ignition timing and engine output for one engine at one speed. With ignition timing set for maximum power, the antiknock requirement is 101.9 octane number. When ignition timing is retarded to 99 per cent of maximum power, the octane requirement is reduced to 99. Thus, engine requirement can be reduced 2.9 octane numbers by sacrificing only one per cent in power.

Equation Predicts Road Octane Number

Using a digital computer, Ethyl statisticians analyzed the vast amount of data obtained from the tests. Extensive correlation equations were developed to aid refiners in blending their gasolines to the actual road antiknock requirements of current and future cars.

The best linear relation existing between road octane number and fuel-inspection data, such as Research and Motor octane numbers and hydrocarbon composition, was determined for each car.

Analysis of these equations showed Research and Motor octane numbers do a good job of defining road gasoline performance at low engine speeds.

At high speeds, however, consideration of gasoline composition, in addition to Research and Motor octane numbers, is useful in predicting gasoline antiknock performance. The correlation equations took the following form:

ROAD OCTANE NUMBER = A
+B *(Research Octane Number)*
±C *(Motor Octane Number)*
+D *(% Olefins)*

where A, B, C, and D are constants determined by analysis.

Additional properties, such as the volatility of the gasoline, do not materially enhance the degree of correlation.

Ethyl studies of the potential of future fuels and engines continue. The results will be distributed to oil companies. The data also will be discussed with automotive companies to acquaint them with the probable composition of future fuels as they may affect future engine design.

We believe such efforts will help to preserve a reasonable relationship between the advantages of high compression engines and their octane requirements.

In Ethyl's extensive road-rating program a digital computer was used to provide maximum statistical interpretation of the test data.

How Ethyl Research Is Helping You

Because of Ethyl's interest in the mutual problems of the petroleum refiner and automobile manufacturer, the extensive research program briefly described here was initiated to define the antiknock performance of future gasolines in tomorrow's engines.

This progress report is one more example of how Ethyl Research—outstanding in the study of engine-fuel relationships—continues to be of service to the petroleum industry.

Copies of the detailed report, "Matching Gasoline Antiknock Performance and Future Engines," presented at the May, 1957 meeting of the API Refining Division at Philadelphia, may be obtained from your Ethyl representative.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

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1600 W. Eight Mile Road, Ferndale 20, Mich.
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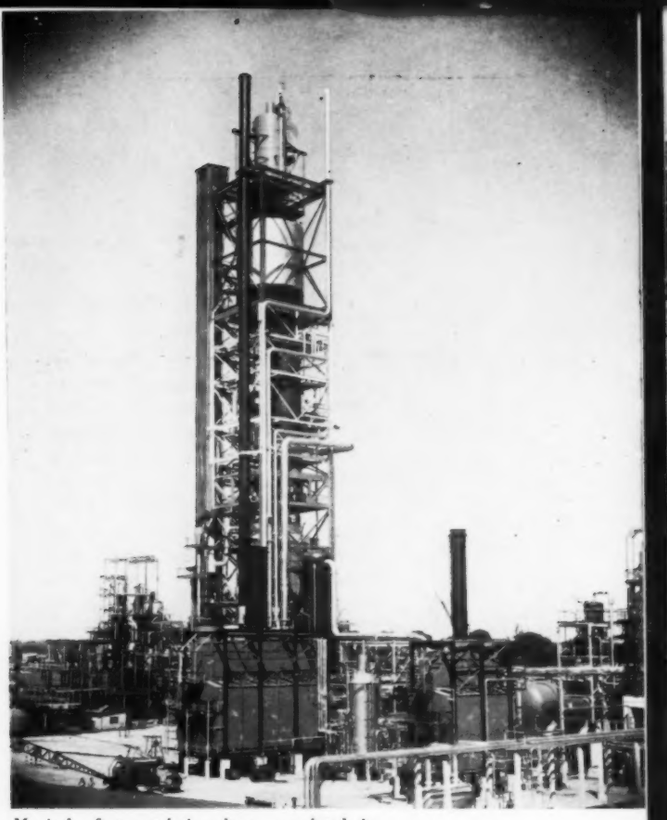


Mexico's first catalytic plant—completed in 1956 at Minatitlán, Isthmus of Tehuantepec.

Three major new refineries completed in less than a year — that is the record of the new . . .

CUBAN REFINING BOOM

WITHIN the space of one year Cuban refining capacity will have risen sevenfold, to a total of 63,500 b/d. Three new refineries are coming on stream this year. This is due partly to new and liberal legislation granting duty exemption to refiners. In larger share, however, it is due to the rapidly rising consumption of Cuba and the surrounding Caribbean area which Cuba can so conveniently serve.

The largest and most complex of the new installations is the Esso Standard S.A. Belot plant which is being built across the bay from Havana. It will replace Esso's present 8,500 b/d Belot refinery. When the new refinery comes on stream late this year the old plant will be removed.

Constructors for the new plant are Arthur G. McKee and Frederick Snare Companies, with Esso Research and Engineering holding the engineering contract and operating as licensors. Esso presently has about 45% of the Cuban market and is investing some $30 million in making this plant the most modern in existence as a supplier to its Cuban and U. S. markets.

A programmed general-purpose analog computer will for the first time become an integral element of oil refinery process control at the new Belot Refinery. Eleven basic operating guides will be calculated by the computer and recorded hourly, along with 101 critical process variables, by an automatic data logger. Esso engineers expect that the major contribution of this data-handling system will be up-to-date operating information that permits closer process control by eliminating error due to time lag caused by conventional manual calculation.

The coordinated automatic data logger and computer has been designed by Fischer & Porter Co. of Hatboro, Pa. to the specifications of Esso Research and Engineering Co. It represents the latest step in automatic data handling toward complete closed-loop process control. The 11 typed operating guides give refinery engineers all the process control information required in digital form each hour with no need for further calculation or human correlation. The 101 process variables, which include both pneumatic and electrical inputs, may be logged on demand at any time by operating a push button. In addition, major process quantities derived from these variables are automatically totalized and recorded every 24 hours. The two electrically-operated logging typewriters also punch all quantities on paper tape, with proper identification and keying, for data storage and accounting analysis on business materials.

The Belot logger-computer has been designed as a general-purpose analog device with automatically programmed solution of process relationships in order to achieve the lower cost, reduced maintenance and small physical space characteristic of modular computer construction. The available operating time of the summation modules, coefficient modules, and multiplication or division modules is programmed and shared to solve for the operating guides with minimum duplication of equipment.

All analogs in the computer will be represented as a-c voltages, thus eliminating the need for precisely regulated and standardized d-c supplies. A-c coupling will be used throughout to avoid random d-c drift in any of the operational modules. Continuous duty cycling with no down-time for balancing adjustment is then expected.

Facilities at the new Esso plant will in-

Aerial view of new refinery of Cia. Petrolera Shell de Cuba SA (photo courtesy of Shell).

clude a two-stage pipestill, a Powerformer, Hydrofiner, fluid catalytic cracking facilities, and a non-selective polymerization unit. Existing lube blending facilities (the only part of the old refinery to be retained) will be used.

The plant is designed to operate on Tia Juana crudes from Venezuela. Tankage includes four 150 by 56 ft. flat roof crude tanks, plus two 150 by 48 ft. tanks and additional tankage totaling some 6,500 tons of steel in all.

American Petroleum Institute separators will be used with five dirty water bays. A 72-inch line will carry effluent water. Three Peerless pumps of 1,500 gpm capacity are contained, run by 600 hp White diesel engines. A 42-inch line will supply salt water for cooling.

The pier in Havana bay has been dredged to accommodate two super tankers at once, up to about 35,000 dwt capacity. Depth at pier is now 38 feet. At the pier is a 26-inch crude line running to storage facilities and four 10-inch discharge lines which are handled by hose-handling structures, power operated. The refinery staff feels that ships will be able to go from customs clearance to discharge operations in about 30 minutes. There is yet to be installed an 18-inch fuel line, a 12-inch ballast water line, two dark and light lube lines, aviation gas and gasoline, lines, and kerosine lines.

Considerable emphasis has been placed by the management of Esso on training Cuban personnel, to the extent that only five foreigners will be used in the entire refinery when it finally goes onstream. About 171 man-weeks of training in the States were given to Cuban personnel and all start-up manuals were translated to Spanish.

A personnel training program got underway in the early part of 1955. The first of two courses for employees in general consisted of a one-hour lecture explaining the reasons for refinery modernization progress, high-lighting the advances made in petroleum refining since 1900, describing the equipment found in a modern refinery and comparing an up-to-date Esso refinery with the then existing Belot plant.

A more intensive course was initiated in November, 1955. This consisted of eight one-hour lectures on the fundamentals of petroleum refining. Though attendance at this course was voluntary, 375 of the refinery's 421 employees enrolled. Of these, 110 voluntarily took in addition to the course, a short written test on each of the subjects covered.

A series of process unit familiarization sessions were held by C. R. Durand, operations assistant, and covered in a general manner flow of products, purpose of units, and operation and maintenance problems. Unit familiarization was also realized as a by-product of meetings conducted by C. G. Morrison, Essosa's manufacturing manager, and F. L. Fourrier, general superintendent of the refinery, to review process and mechanical specifications of the new equipment.

Several sessions were held by the refinery's process supervisors with the shift foreman. The sessions were designed to familiarize the foreman with the general layout and operation of the new units. The on-the-spot training program began on March 26, 1956, with the arrival of the first Belot employee at Esso's Bayway refinery in New Jersey. In the period between March and September, 1956, 33 employees visited seven locations for a total time of 171 man-weeks of contact training. Places visited by various Belot employees were the Esso Research and Engineering Co., laboratories and the Bayway, Everett, Baltimore and Baton Rouge refineries in the U.S.A., Amuay Bay refinery in Venezuela and the Standard Inspection Laboratories.

Personnel receiving contact training included supervisors, engineers, technicians and shift foremen. Prior to their departure, the trainees attended three 1½ hour conferences to discuss what they were to look for on their visits and what was expected of them. The contact training at the various locations was thorough and included inspection and familiarization of all types of equipment and processes similar to those being installed at Belot.

Upon return from contact training, the process supervisors undertook the job of writing operating manuals for specific units similar to Belot's new installations which they had seen at other refineries. Considerable experience is gained through this.

The technical training program at Belot was started on Oct. 7, 1956, by Dr. George Mitchell, who is on loan from the Baton Rouge refinery. This advanced course is now in progress and is attended by supervisory and technical personnel. Meetings lasting two hours are held three times each week. The subject matter includes process and laboratory operations, engineering principles, technical service methods and calculation methods. Interest among Belot personnel in this course is at a high level.

The chief chemist at Belot, Ricardo G. Abreu, completed a laboratory procedure orientation manual in Spanish. This manual will be used as one of the texts for laboratory training. In addition, the Belot laboratory is translating into Spanish all standard test methods applying to the new laboratory equipment. This material will be compiled in a manual and distributed to all Belot laboratory personnel. Essosa will distribute this material later to terminals and sales groups. Limited on-the-job training is at present underway in the laboratory on equipment which will be used in the new refinery.

Texaco's Santiago Refinery. At the extreme eastern tip of Cuba The Texas Co. has completed a modern 20,000 b/d plant. Built across the bay from Santigo de Cuba, the refinery site was a wild unsettled area that did not even have an access road before the company bulldozers moved in. Now the town of Santiago can be reached in 15 minutes on a modern surfaced highway which has opened up all the surrounding area.

The harbor entrance was dragged to a depth of 40 feet to admit large tankers, the cost paid by Texaco and later to be recovered by tax remissions. The plant will operate on Venezuelan crude (probably Mara). A 1,000 ft. pier accommodates two 700-ft. super tankers simultaneously with 40-ft. draft.

Contractor for the job is Procon International S.A. Facilities include a 3,300 b/d Platformer a 4,000 b/d hydrotreater, sulfur removal facilities of 4,100 b/d capacity and a 20,000 b/d crude unit. There are LPGas facilities, and a copper sweetening unit. Also to be included in the plant's facilities are a 200 b/d Linde gasoline treating unit, plus modern fire fighting and fire protection equipment.

The plant is operated onstream and has three large boilers with a fresh water cooling system. The problem of water supply was solved by drilling six wells of four million gallons per day capacity in the area, despite predictions by all local sources that water could never be found. A 10-inch pipeline about six miles long is being built by the company to supplement Santiago's water system.

One of the principal inducements to Texaco to build the new plant was Law Decree 1758 which encouraged investment of foreign capital in Cuban refining operations through tax advantages.

Shell's Belot Refinery: Shell's new 28,500 b/d refinery at Belot went onstream in mid-

January 1957. The company figures show a distillation unit capacity of 27,000 b/d and a Platformer of 5,000 b/d capacity. There are also included some LPGas facilities.

Crude stock is Lagomar and Oficina crudes from Venezuela. Feed stocks from the Platformer are naphtha fractions for these crudes and have a boiling range of 185°F. to 365°F. From these fractions the Platformer will produce a 97 leaded octane blending component.

The tanker jetty is about 1,000 ft. in length and will accommodate ships up to 39 ft. draft. Bechtel International engineered the plant, with construction of dock facilities by the Cia. de Contratistas Independientes, S.A. of Havana.

The refinery has no lube can shop. Lube drums will be filled at the plant, primarily for the Cuban market. Distribution facilities on the site include warehouses, truck loading platforms, and railway tank cars. There are about 50 storage tanks with a total capacity of 1,550,000 barrels. Fresh water storage, (obtained from the municipality of Regla) is 15,000 barrels.

Primarily Cuban personnel will be used, with H. Van Lente, manager, and D. Tol and R. Storm, superintendent and construction and maintenance engineer respectively, replaced by Cubans within a few years. Some 20 Cuban engineers have been taking intensive training courses 18 months to two years in Holland and England for the job, preparing for the day when the $25 million plant will be run entirely by Cuban personnel.

Refinery expansion is under way or planned in a number of other areas in Latin America as refiners seek to keep abreast of the rapid increase in petroleum consumption. Most recent announcement of a major unit is the 55,000 b/d refinery planned for construction at Colon, Panama, by Panama Refining and Petrochemical Co. Inc., Foster Wheeler is prime contractor for the plant which is expected to be completed in about two years. The company is reported to have sold the entire output of the proposed refinery for 10 years to a group of companies which market in the general area.

Shortly before the Panamanian project was announced the U. N. Economic Commission for Latin America and the Central American Cooperative Committee issued a report suggesting the erection of a refinery in Central America. The Central American Committee is composed of the economy ministers of Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua.

Oil consumption in the five nations averaged 16,000 b/d in 1954 and 17,000 b/d in 1955. Average rate of increase is 6% per year. Consumption in 1960 is expected to reach 20,300 b/d and 26,000 b/d in 1965.

The U. N. committee concluded after making its study that none of the small nations could now support a refinery but through integration of the market a plant would be justified. It is not known at the moment whether the new Panamanian plant will be considered by the U. N. committee to meet the requirements of the region.

Petroleos Mexicanos has been engaged in a continuous building program for many years and the current situation is no different. At Mata Redonda, Vera Cruz, it is planned to increase crude capacity 20,000 b/d and a grease plant and a 15,000 b/d cat cracker are to built at Salamanca. This will be Mexico's second cat cracker, the first unit of 15,000 b/d capacity having been activated at Minatitlan recently.

In Puerto Rico Commonwealth Oil Refining Co. has completed major additions recently. Crude capacity has been stepped up 55,000 b/d and a new cat cracker has been built with a total charging capacity of 53,000 b/d.

In Colombia International Petroleum (Colombia) Ltd. will complete its new Cartagena refinery late in August. The plant has a crude capacity of 26,500 b/d and is equipped with a catalytic cracking plant with a raw charge capacity of 13,130 b/d.

As described in some detail in the July 1 issue of WORLD PETROLEUM which devoted itself exclusively to Venezuela, the refining industry in that country is engaged in a major refining expansion.

Creole Petroleum Corp. has increased its crude capacity 72,000 b/d at Amuay Bay during the past year and now has a throughput capacity of 250,000 b/d. An additional crude unit of 104,000 b/d capacity will be completed by October of this year. A lube plant is under construction which will produce 650 b/d and a 17,000 b/d Hydrofiner is planned.

Compania Shell de Venezuela Ltd. has increased its crude capacity from 145,000 to 203,000 b/d within the past year and has projected another 80,000 b/d distillation unit for 1958 completion. A 2,300 b/d alkylation unit will be complete within the next three months as will a new 35,000 b/d cat cracker.

Venezuela Gulf Refining Co. will complete an 8,660 b/d fluid cat cracker early in 1958. Richmond Exploration Co. is planning a 20,000 b/d crude increase and Phillips Oil Co. is considering a crude unit at its San Roque wax plant.

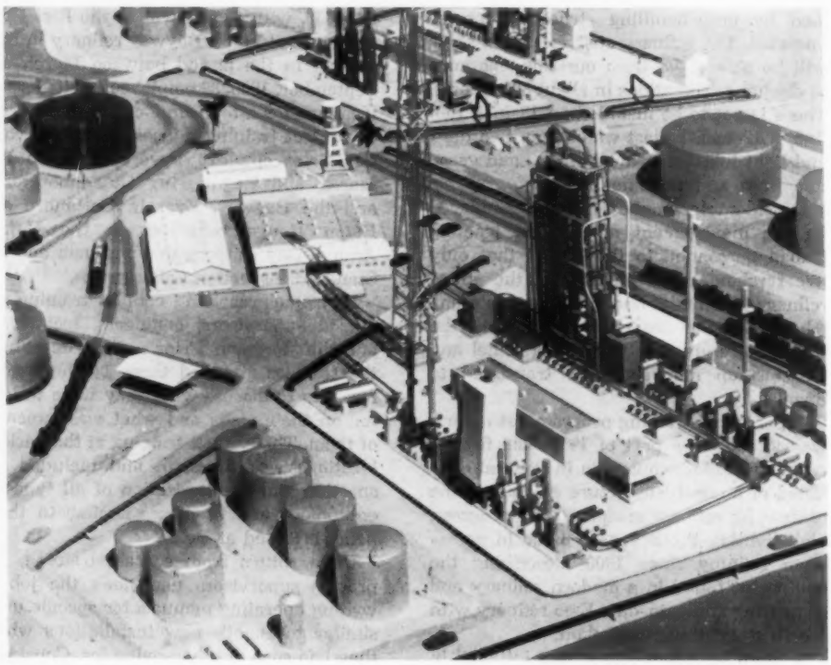
In Ecuador Anglo Ecuadorian Oilfields Ltd. will complete a 7,700 b/d crude unit and 6,000 b/d UOP thermal cracker in 1958.

In Bolivia YPF is building a 1,500 b/d Platformer at Cochabamba.

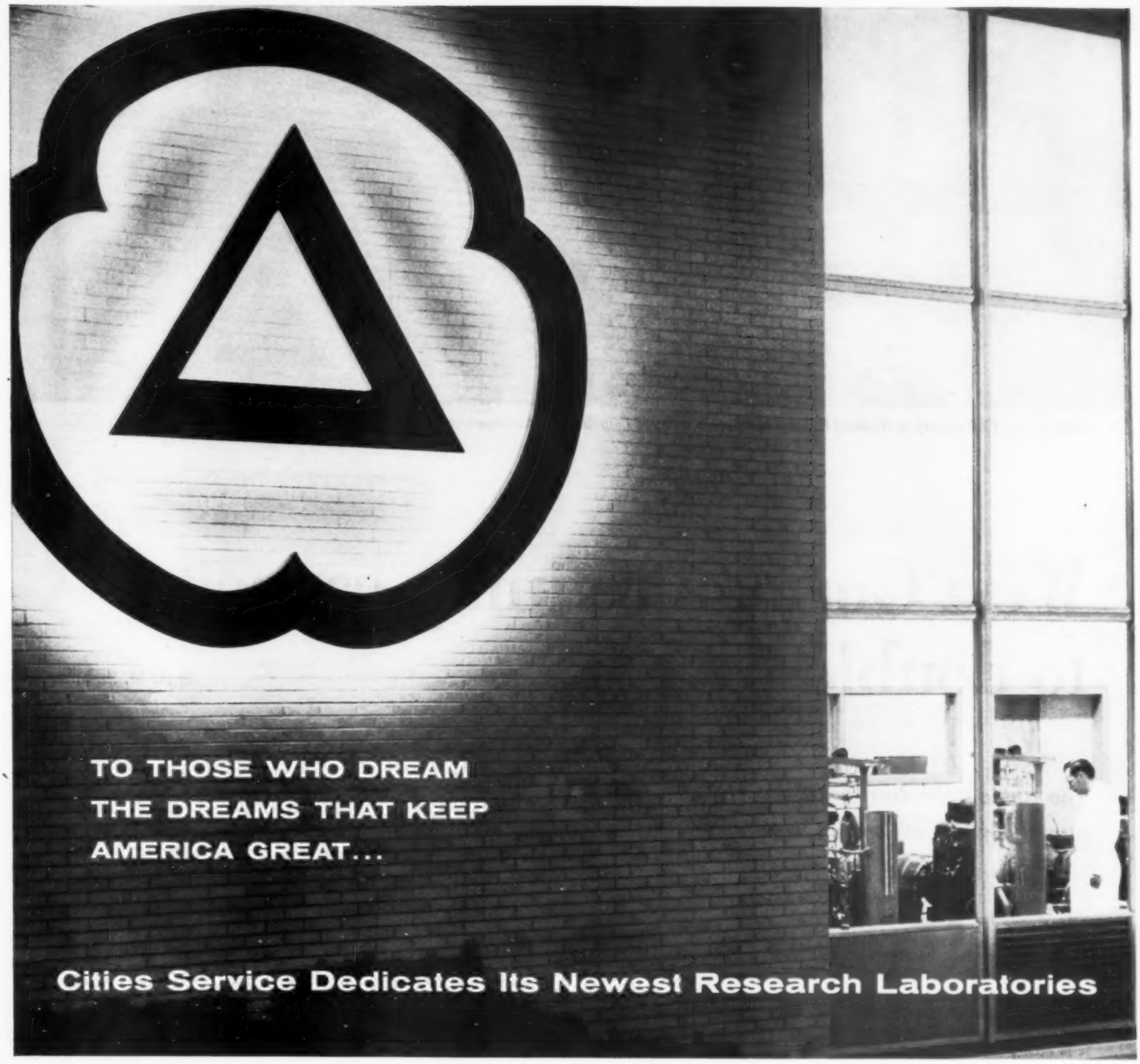
Brazil is another boom area in which refinery construction is continuing at a rapid rate. Early in 1958 Petrobras will complete a 32,000 b/d addition to its Mataripe plant. The Presidente Bernardes refinery is to be enlarged to 90,000 b/d and the Government company is considering the erection of an 80,000 b/d plant in the Federal District and possibly two other large refineries.

In Chile Empresa Nacional del Petroleo expects to add 30,000 b/d to the topping capacity of its Concon refinery, a 12,000 b/d cat cracker and 6,000 b/d cat reformer. The present thermal reformer will be revamped as an 8,000 b/d crude unit. Completion of the project is planned for 1959.

Demand continues to rise in Argentina and YPF is considering a number of schemes for expansion of its manufacturing facilities. Currently a 28,000 b/d crude still is being built at the Lujon de Cuyo (Mendoza) refinery. Completion is anticipated in 1958. END



Scale model of Belot refinery (photo courtesy of Esso Standard SA).



Cities Service believes it is altogether fitting that its splendid new research laboratories at Cranbury, New Jersey be dedicated to those who will use them so wisely and well.

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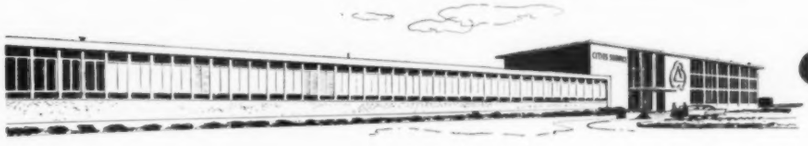

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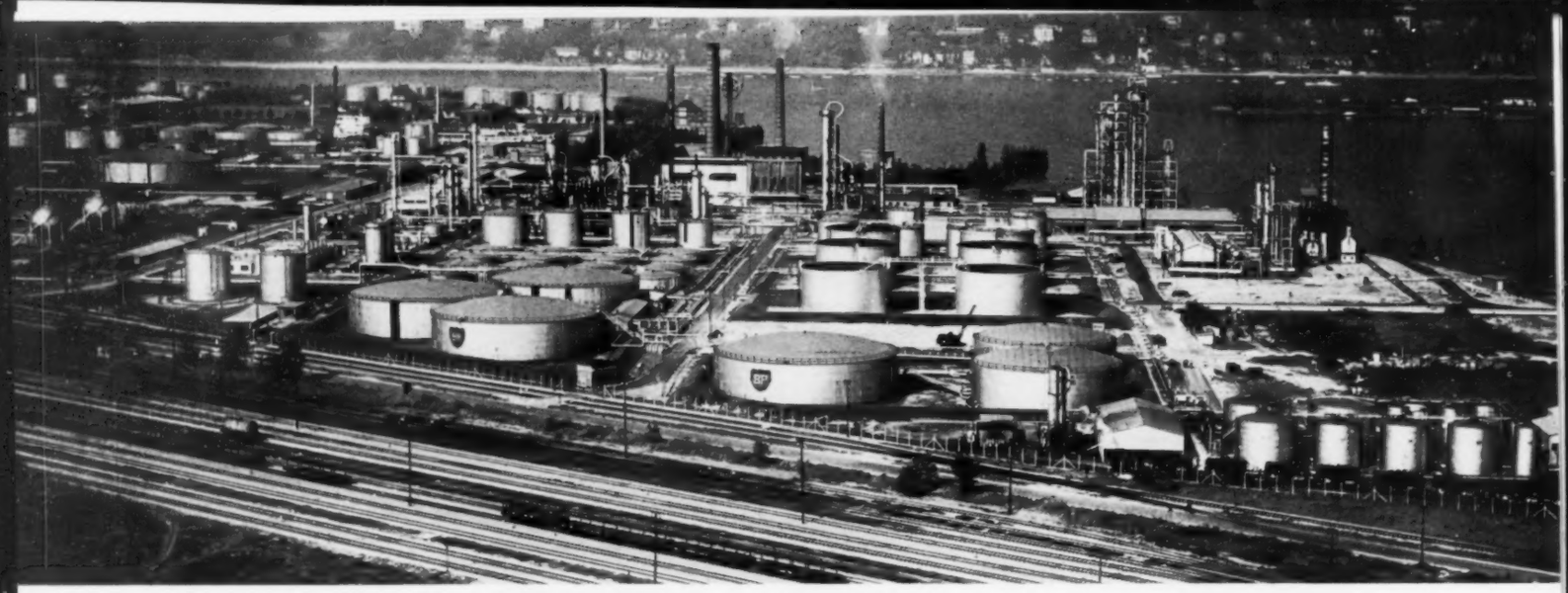


General view of BP refinery at Hamburg-Finkenwerder (photo, courtesy Luftreisedienst Niedersachsen GmbH).

West German refining capacity to double by 1965

by A. M. Stahmer

The Rhine-Ruhr district will see the construction of four major refineries with an aggregate ultimate capacity of 135 million barrels per year. Emphasis on fuel-oil production is growing.

THE growing oil consumption of West Germany, which rose 27% in 1956 to 107 million barrels (including bunkers), caused the oil companies to work out plans for a further increase of refining capacity. It is obvious that the first stage of refinery expansion which was started at end of the 40's did not keep pace with the development of the oil market of the country, and in 1956 the annual crude-intake capacity with 103 million barrels, i.e., nearly the same figure as one year before, was far below demand.

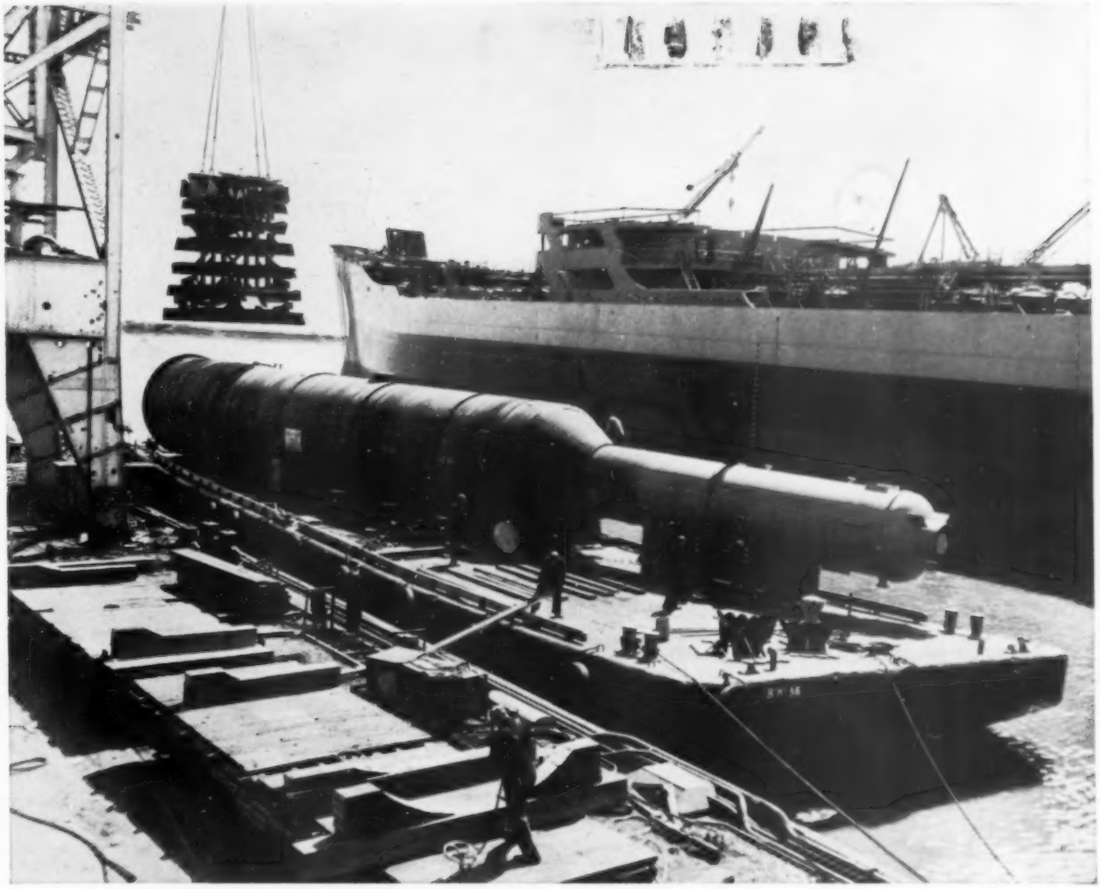
In 1956, the refineries produced 77.9 million barrels of finished products, thus remaining 29.1 million barrels below the consumption figure, to say nothing of the traditional export deliveries to Scandinavia and other areas which totaled 8.6 million barrels.

Market-research experts estimate that, due in the first place to a sharp increase of fuel-oil sales, the total mineral-oil consumption of West Germany will amount to 255.7 million barrels in 1965, i.e., twice as much as the forecast for 1957. In the light of these figures, it can easily be understood that the leading oil companies decided to build new plants in the Rhine-Ruhr district, the industrial center of the country, and thus also the most important area for marketing oil products.

In our last year's report, we published details on the plan of Esso AG (Jersey Standard affiliate) to erect a refinery at Cologne on the Rhine with an annual intake capacity of 21 million barrels in the first, and 35 million barrels in the second, construction stage. In the meantime, Esso confirmed that a modern steam cracker for the production of gaseous olefins from distillate gasoline (naphtha) at high temperatures is to be attached to the refinery, the costs of which are estimated at about $15 million. Part of the olefins produced is to be conveyed by pipeline to the chemical industry which will use it for the manufacture of petrochemicals. Site preparation for the Cologne refinery has already been started.

Some months ago Deutsche Shell AG announced details on its new large-scale refinery project. Shell intends to build a plant at Godorf near Wesseling on the Rhine (south of Cologne) with an initial annual crude-intake capacity of 30 million barrels, which later is to be stepped up to about 50 million barrels. The refinery will mainly produce fuel oil from Kuwait or Iraq crude. In addition to the distillation units, a Platformer, a diesel-oil desulfurizer, and a Claus unit for the recovery of sulfur are to be installed on the 500-acre site at Godorf. Cost of the refinery, which is to be put into operation late in 1960, is estimated at $60 million. At a throughput of Kuwait crude, the yield would be approximately 56% fuel oil, 23.3% diesel oil, 6.5% gasoline, 5.9% special products, and 5% jet fuel—the balance being fuel gas, sulfur, and refining losses.

As in its new plant at Hamburg-Hohe Schaar, Deutsche Shell will build recooling towers at Godorf to economize to a maximum on cooling water. By the equipment of storage tanks with floating roofs, the employment of fully automatic burners and mechanical seals, air pollution is to be reduced to a minimum. The excavation work for a new oil harbor on the Rhine, at Godorf, has already been started.



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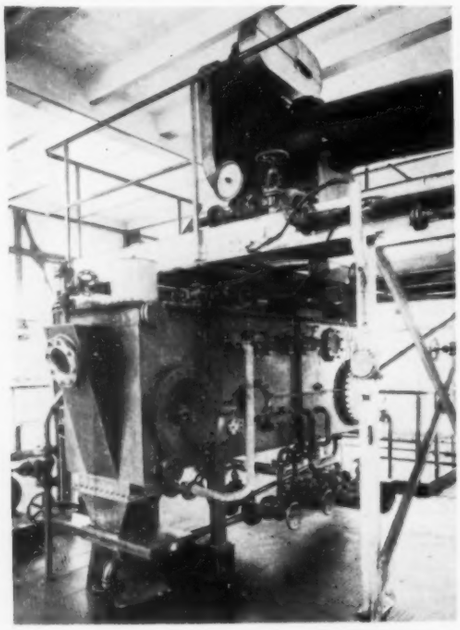


Interior of the urea dewaxing plant of Deutsche Erdoel AG at Heide.

The newly erected Sovaformer of Mobil Oil at Bremer-Oslebshausen (Mobil Oil photo).

In its annual report for 1956, British Petroleum Co. Ltd. mentioned the plan for the erection of a new BP-refinery with an intake of approximately 30 million barrels per annum in the Ruhr area, which is to be put onstream as early as 1960 for the production mainly of fuel oil. Apparently, a site on the Rhine River also will be chosen. After the completion of the plant BP, as well as Esso and Shell, will each have efficient refineries at Hamburg and in the Rhine-Ruhr district.

Another new project is that of Compagnie Financière Belge des Pétroles SA Petrofina, Brussels, which intends to build a refinery with an initial throughput of seven million barrels, which later is to be increased to 20 million barrels. The site of this plant is an area on the Rhine, at Duisburg-Nuenkamp. A new company has been formed under the name of Purifina Mineraloelraffinerie Aktiengesellschaft, with head office at Duisburg, which is to carry out the project. Petrofina supplied this company with a capital of 5 million D marks ($1.2 million). For the first stage of construction, a capital investment of approximately $17 million is planned. The plant is also to produce maximum yields of heavy and medium-heavy fuel oil. Fuels of highest quality only will be produced.

Not far from the area of the new Shell refinery at Godorf, Union Rheinische Braunkohlen Kraftstoff AG runs a refinery and hydrogenation works at Wesseling. The company, in short called Wesseling, has a processing agreement with Deutsche Shell AG which will expire in 1963. While Shell will soon have a production plant of its own in the western part of the country, it is to be expected that Wesseling sooner or later will contact other marketers in Germany who have had no refining facilities up to now. At present, Wesseling produces high-grade fuels mainly by cracking and hydrogenating residuums to obtain a maximum yield of gasoline and diesel oil. This method of processing minimizes existing distillation capacity. If Wesseling switches over to fuel oil and straight-run gasoline only, and maintains a high-quality product with the help of the newly erected UOP-Platformer (capacity 5,600 b/d), the crude-intake capacity could be increased to 21 million barrels annually from about nine million.

All companies mentioned above participate either in the Wilhelmshaven-Wesseling or in the Rotterdam-Godorf pipeline projects—the latter being a section of the planned Sappeur pipeline system. The pipeline from Wilhelmshaven to Wesseling will be completed as early as the spring of 1959. Its length is about 220 miles; the diameter 28 in. The Rotterdam-Godorf section will be put onstream by the end of 1960—length being about 150 miles.

At Hamburg, the traditional center of the refining industry, the growth of the crude- and distillate-treating potential made further progress. Esso AG announced that the intake capacity of its refinery at Hamburg-Harburg, which at present is 16.5 million barrels annually, will be increased to 21 million barrels in 1959. As already described in our last year's report, a Hydrofiner and a fluid-bed Hydroformer are now onstream there.

At Hamburg-Hohe Schaar, construction of the new plants of Deutsche Shell AG is going on. While the completion of the first of two UOP-Platformers had already been reported in May 1957, the erection of a hydrodesulfurizer for gas oil (intake capacity 5,500 b/d) has meanwhile been finished. The process applied is the trickle method by Bataafsche Petroleum Mij.

The expansion of the works of Mobil Oil AG at Bremen-Oslebshausen made considerable progress in 1956, and in the early

TABLE I

West German Consumption (Percentage of Various Oil Products)

	1st Quarter 1955	1st Quarter 1956	1st Quarter 1957†
	(Thousands of Barrels)		
Total quantity	19,778	17,500	22,939
	%	%	%
Gasoline	24	21	21
Diesel and gas oil	30	22	22
Lubricants	5	4	3
Bitumen	4	3	4
Fuel oil*	27	39	41
Others	10	11	9
	100	100	100

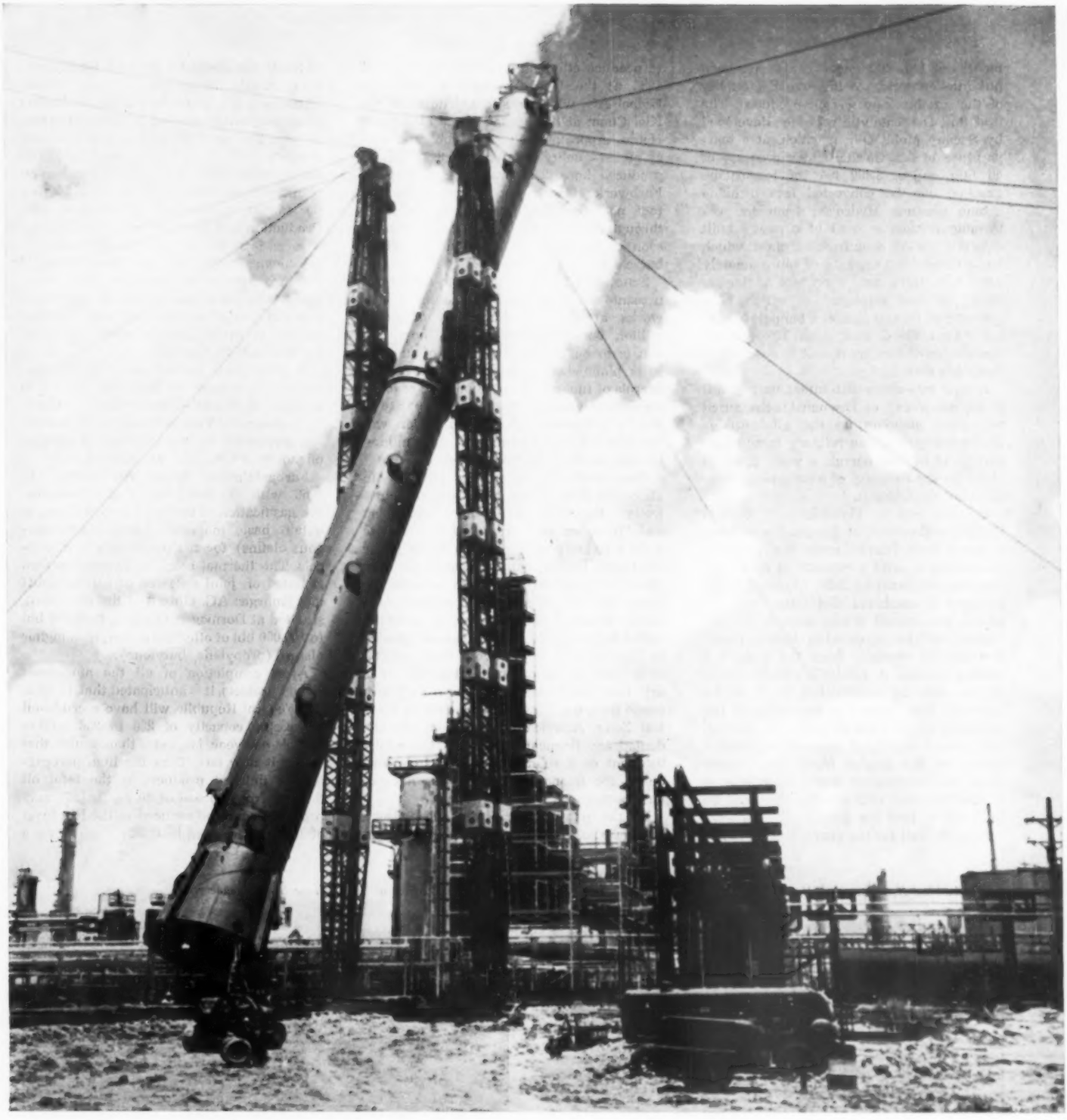
* Including refinery consumption and bunker liftings to German-flag ships.
† Preliminary figure.

TABLE II

Annual Capacity of West German Cracking and Reforming Plants (December 31, 1956, in Thousands of Barrels)

	Catalytic* Cracking	Thermal† Cracking	Catalytic Reforming	Thermal Reforming	Hydrogenation
BP	—	1,470	1,750	1,050	—
DEA	2,520	—	—	—	—
Deurag-Nerag	—	1,720	840	—	—
Esso	3,790	—	2,140	—	—
Gelsenberg	3,150	—	2,100	—	5,040
Lingen	6 020	—	910	—	—
Mobil Oil	2,520	—	1,120	—	—
Ruhrchemie	1,120	700	580	—	—
Ruhroel	—	—	—	250	—
Scholven	1,680	—	700	—	3,150
Shell	—	—	700	—	—
Wesseling	—	3,850	1,860	1,540	2,310
	20,800	7,740	12,700	2,840	10,500

* Including recycle.
† Without recycle.



"Over the years, Jersey's expenditures for capital equipment, and costs relating to the search for and development of new oil reserves, have been very large. For the current year they will amount to $3 for each $2 of last year's profit."

— M. J. Rathbone, President, Standard Oil Company (New Jersey)

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months of 1957. Two new plants have been put into operation to improve the quality of the gasoline and gas oil produced. The first unit is a catalytic reformer developed by Socony Mobil Oil, in which, at a temperature of 525 Celsius and a pressure of 40 atm gauge, 3,400 b/d of low-octane gasoline can be converted into a high-octane product. Hydrogen from the reforming process is used in a newly built catalytic gas-oil desulfurizing plant, which has a throughput capacity of approximately 5,000 b/d. Here, too, a process of Socony Mobil Oil was employed, in which, at a pressure of 60 atm gauge, a temperature of more than 400 C is applied. The product receives secondary treatment in an electrostatic lye washer.

A new two-stage distillation unit is still to be completed at Bremen-Oslebshausen this year, stepping up the total crude-intake capacity of the refinery to approximately 10 million barrels a year. A Claus plant for the recovery of elementary sulfur is under construction.

On the site of Gewerkschaft Erdoel-Raffinerie Emsland, at Lingen-Holthausen, a newly built Houdriformer with a platinum catalyst, with a capacity of 2,800 b/d, was put onstream in 1956. Lingen intends to erect a combined distillation unit by which the annual crude capacity of the refinery will be increased by 1958 to 7 million barrels annually from the present 5 million barrels. A catalytic gas-oil desulfurizer will be constructed. It is to be expected that, after the expansion of the available crude-treating potential, Lingen will import additional amounts of foreign crude via the Emden North Sea harbor since the indigeneous crude oil produced in the Emsland district will then not be sufficient to feed the plant.

A Linde unit for the disintegration of gas to produce ethylene was completed late in 1956 at the Heide refinery of Deutsche Erdoel AG, which is situated north of the Kiel Canal at the border of the oil field of Heide. Approximately 7,000 bbl annually of purest-quality ethylene (99.8%) can be produced here. The product is shipped to Farbwerke Hoechst at Frankfort-Hoechst for petrochemical manufacture. Crude throughout capacity of the Heide plant is soon to be expanded to about 10 million barrels a year.

Scholven Chemie AG plans to double the present crude-processing potential of its works at Gelsenkirchen-Buer of seven million barrels annually. Also, here, the aim is to begin the production of fuel oil. It is planned to yield about five million barrels of fuel oil a year. By means of technical improvements, the annual capacity of the hydrogenation plant at Scholven was increased by approximately one million barrels, to three million barrels.

Considerable attention was attracted in May this year when Mr. Gottlieb Duttweiler, the well-known Swiss politician and "price cutter," published his plan to erect a refinery at the Emden harbor, near the Dutch border, with a capacity between 20,000 b/d and 30,000 b/d to provide the Swiss and the German oil market with cheap products. Up to now, a company called Erdoelwerke Frisia AG was founded in Emden with a relatively small capital of 500,000 D mark (about $120,000). It is said that Duttweiler intends to treat Wafra crude from the Kuwait-Saudi-Arabia Neutral Zone. American Independent Oil Co. denied any financial interest in the establishment of a refinery at Emden. Apparently, the financing problem has not yet been settled by Mr. Duttweiler.

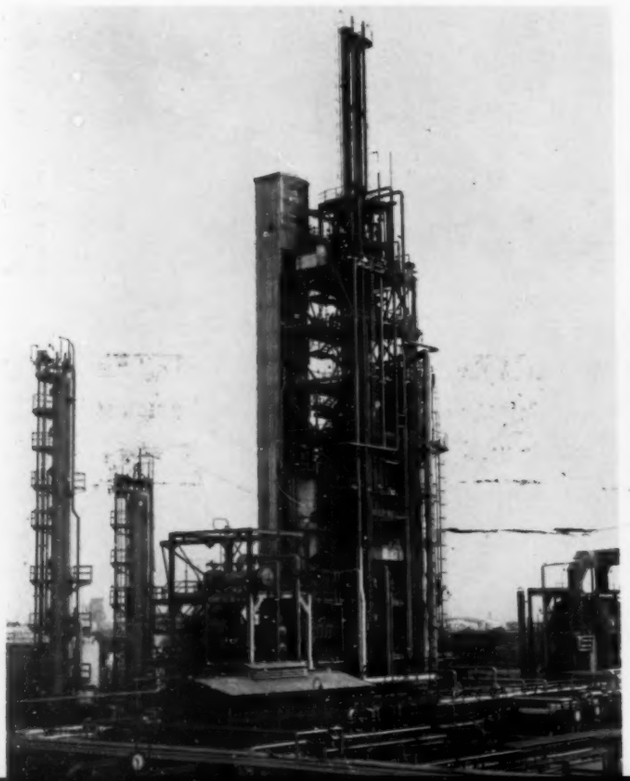
In the petrochemical keld, Rheinische Olefinwerke, at Wesseling, a joint interest of Shell and Badische Anilin & Sodafabrik, is to treble its output of polyethylene (Lupolene H), a product which is finding an ever-growing market in West Germany. Within the next three years the annual capacity is to be increased to 250,000 bbl from 70,000 bbl. An epicote production plant, with an initial capacity of 14,000 bbl per annum, is to be built by mid-year 1958. Production will be based on propylene recovered from the oil cracking. By a chemical conversion process, epichlorohydrine is obtained from propylene which, when combined with bis-phenol, yields by condensation the synthetic epoxy resins from which epicote is made. Epicote paints also find market in West Germany.

A pilot plant to test the polyethylene-production process of Professor Ziegler is working at Phenol-Chemie GambH, Gladbeck-Zweckel. This petrochemical factory has increased its capacity for producing phenol to 125,000 bbl per annum.

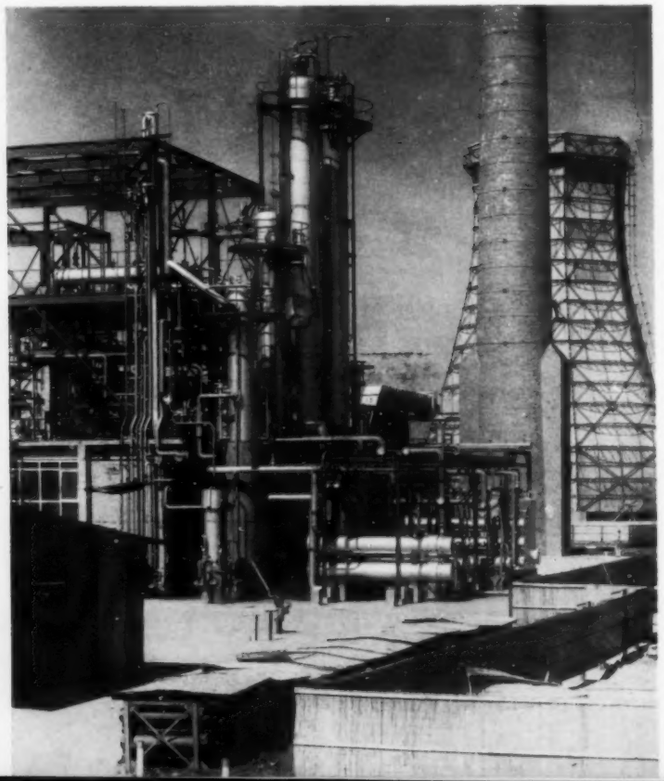
Farbenfabriken Bayer AG started, in 1956, with the construction of a plant for the gasification of crude oil or distillates, to obtain basic materials (particularly gaseous olefins) for the production of chemicals. The thermal cracking method applied is based on joint research of Lurgi GmbH and Ruhrgas AG. Output of the new plant, situated at Dormagen (Rhine), is 80,000 bbl to 100,000 bbl of ethylene a year, plus higher olefins (propylene, butylene).

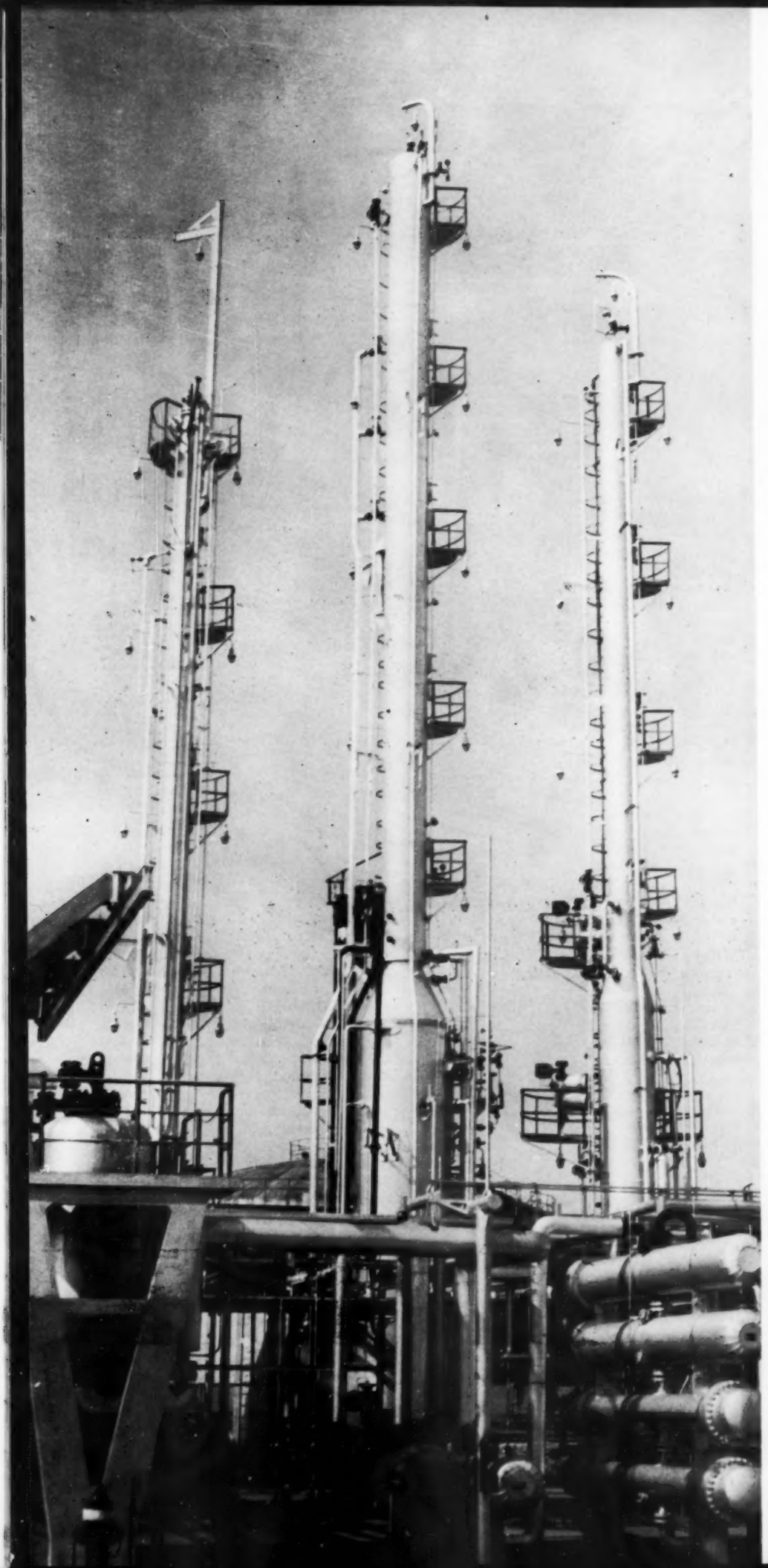
After completion of all the aforementioned projects, it is anticipated that, in 1965, the Federal Republic will have a crude-oil processing capacity of 220 to 250 million barrels per year, i.e., more than double that which it now has. Then the high percentage of finished products in the total oil imports from abroad of 30.6% in 1956 may probably again be reduced to the low level of 13% experienced in 1953. END

Esso's fluid-bed Hydroformer at Hamburg-Harburg (Esso photo).



Gas-oil desulfurizer at Shell's Hohe Schaar refinery.





ITALY SETS NEW RECORDS

Crude runs, domestic demand, and exports reach new levels in 1956. Suez crisis brings short pause in octane race. Petrochemical activity increases.

by Alberto Girelli

THE Suez Canal crisis, an outstanding event affecting the petroleum industry in Europe, did not hurt Italian industry as severely as it did industries in other European countries. This was true even though the Cape of Good Hope route is extremely disadvantageous to Italy. This route is comparatively longer for Italy, situated in the very center of the Mediterranean Sea, than for France or Great Britain.

Refineries located on the Adriatic coast from Trieste to Bari, which rank among the largest of the country, would have been more severely handicapped by the longer route. From Gibraltar to Trieste or Venice, tankers must travel one whole day longer than to Genoa or to Naples. Fortunately, Aramco's Tapline was undamaged. Crude oil reached the Sidon terminal, where the local Lebanese authorities had forbidden loading of tankers under French and British flag, but did not object to Italian tankers. As a result, a large share of the Italian oil demand was satisfied by Middle East crude, which Italian refineries have processed since the end of the war.

Catforming plant at refinery of Italia SpA Raffineria, at Cremona.

A second factor playing a major role during the crisis, in favor of Italy, was the extremely mild winter season in North Italy, where domestic and commercial heating rely heavily on the supply of residual fuel oils.

Supplies of crude from other areas (mainly from Venezuela, USA, Gulf Coast, Russia, (and eastern Europe) also contributed to the solution of the Italian oil problems. The difficulties posed by the sudden change of crude-oil type have been easily overcome by Italian refineries, with some exceptions. The very high salt content of some Russian crudes (up to 0.2% by weight) is likely to show its effect in the future in plants which have run these oils.

Increased domestic production of crude (12,200 b/d in 1956) and of natural gas (about 4.7 billion cubic metres) also contributed to fill the gap. As a matter of fact, Italy was alone among the western European countries which consume much more oil than locally produced in not suffering from restrictions in the products trade and distribution.

The only measure taken by the government was an increase in the retail price of gasoline (to 142 lira per liter from 128, regular-grade, and to 152 lira per liter from 138, premium grade). The price increase, together with a tax decrease of 11 lira, will be used to pay refiners the increased expenses due to higher crude prices and tanker freights. This step was taken to keep down the price of oil products of more direct impact on industrial costs (such as gas oil and residual fuel) and, through these, on the general cost of living. The increased gasoline price is officially stated to be "temporary." Recent information from official sources is that the increased price is to be maintained until midyear 1958 at least.

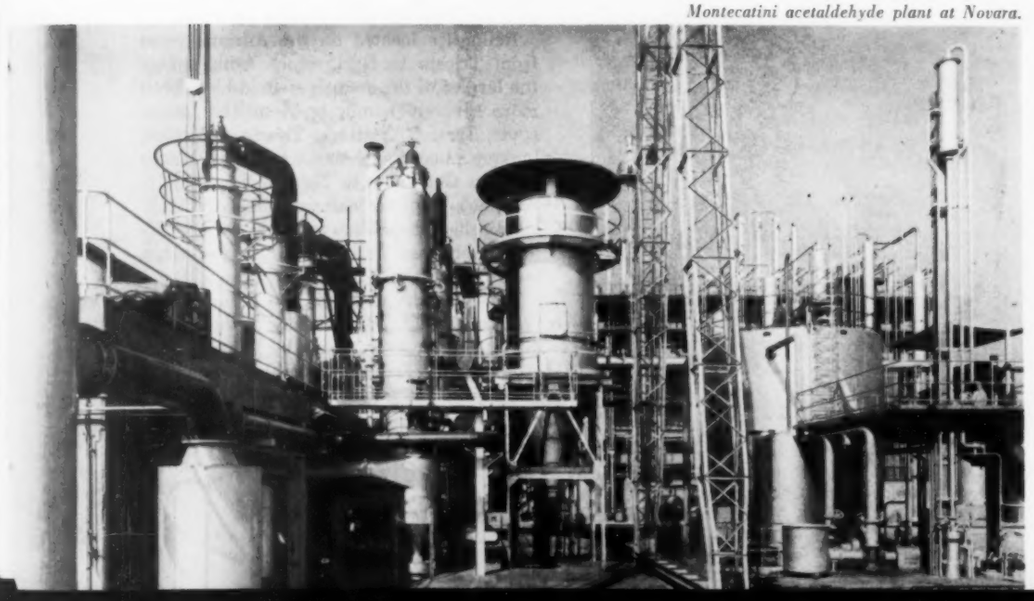
No shortage of products has been felt by the consumers—stocks of white products being very high at the time of the canal closure, at the beginning of the "off season" for gasoline.

Quality of products was rather soon impaired, however, without great nuisance to the consumers—minimum specifications being established by law. Gasoline octane number at the pump station decreased to 80-82 RM from 84-86 RM for the regular-grade, and to 92-94 RM from 98-100 RM for premium-grade—bringing to a temporary halt the octane race which had brought the octane level of gasoline marketed in Italy to the highest level in Europe, without a real need from the automobile engines operating in the country. The race is on again, and gasoline quality is presently up to the pre-Suez level.

Total imports of crude in November and December 1956 decreased 436,000 tons (about three million barrels) as compared to the corresponding months of 1955; exports decreased 271,000 tons. Fuel-oil imports increased 168,000 tons. Complete data of the Italian refining activity for the whole year, as compared to 1955, are reported in Tables I through III.

Apart from the Suez emergency, the Italian refining industry in 1956 continued its expansion, aiming more at higher product quality than at increased crude capacity. A certain concentration has been noticed, with the smaller refineries being progressively shut down or absorbed by larger groups. Very active in this area is the government-owned ENI, which joined Purfina Italiana in the construction of a new refinery near Rome (probable capacity 30,000 b/d) to supplant the old Purfina refinery in Rome, which is to be dismantled. The new enterprise, named "Raffineria di Roma SpA," is a 50-50 partnership. The refinery will be erected near Fiumicino, at the Tiber River delta. Completion in 1959 is planned. Another ENI enterprise is the purchase of a large majority (80%) in the STOI refinery near Florence, which is being completely rebuilt. A 40-mile pipeline to the Thyrrenian Sea is to be built. STOI also owns a good motor-fuel distribution net work in Tuscany, which will now carry the AGIP (ENI) colors. With the recent expansion, ENI controls a large share of the Italian refining capacity, through the refineries at Cortemaggiore (wholly owned) at Bari and Leghorn (partner Jersey Standard) and at Porto Marghera near Venice (partner the British Petroleum Co.).

Montecatini acetaldehyde plant at Novara.



The year 1956 set new records for the Italian refining industry, with 386,000 b/d crude run to stills and 360,000 b/d imported during the year (against 338,000 b/d in 1955) and the rest from domestic crude and from existing stocks. The imbalance due to consuming needs taking a divergent trend from refinery output is still aggravating. There is a surplus of white products and shortage of residual fuel, the use of which is continuously increasing—mainly for industrial purposes and for electric-power generation.

TABLE I
ITALIAN REFINERY RUNS BY PRODUCTS (1955-56)
(Thousands of Metric Tons)

	1955	1956	% Change
Crude run to stills	17.600	19,300	+ 9.6
Products:			
Gasoline	2,718	3,100	+14.6
Jet fuel and kerosine	1,114	1,170	+ 5.3
Gas and diesel oil	3,586	3,950	+10.1
Residual fuel	7,774	8,500	+ 9.4
Lubricants	157	170	+ 9.1
LPGases	281	350	+24.5
Bitumen	391	435	+11.2

TABLE II
ITALIAN CONSUMPTION OF PRODUCTS (1955-56)
(Thousands of Metric Tons)

	1955	1956	% Change
Gasoline	1,344	1,450	+ 7.8
Jet fuel and kerosine	266	300	+12.7
Gas and diesel oil	1,570	1,730	+10.1
Residual fuel	5,200	6,400	+23.1
Lubricants	168	190	+13.0
LPGases	330	390	+18.2
Bitumen	333	380	+14.1

TABLE III
PRODUCTS EXPORTS FROM ITALY (1955-56)
(Thousands of Metric Tons)

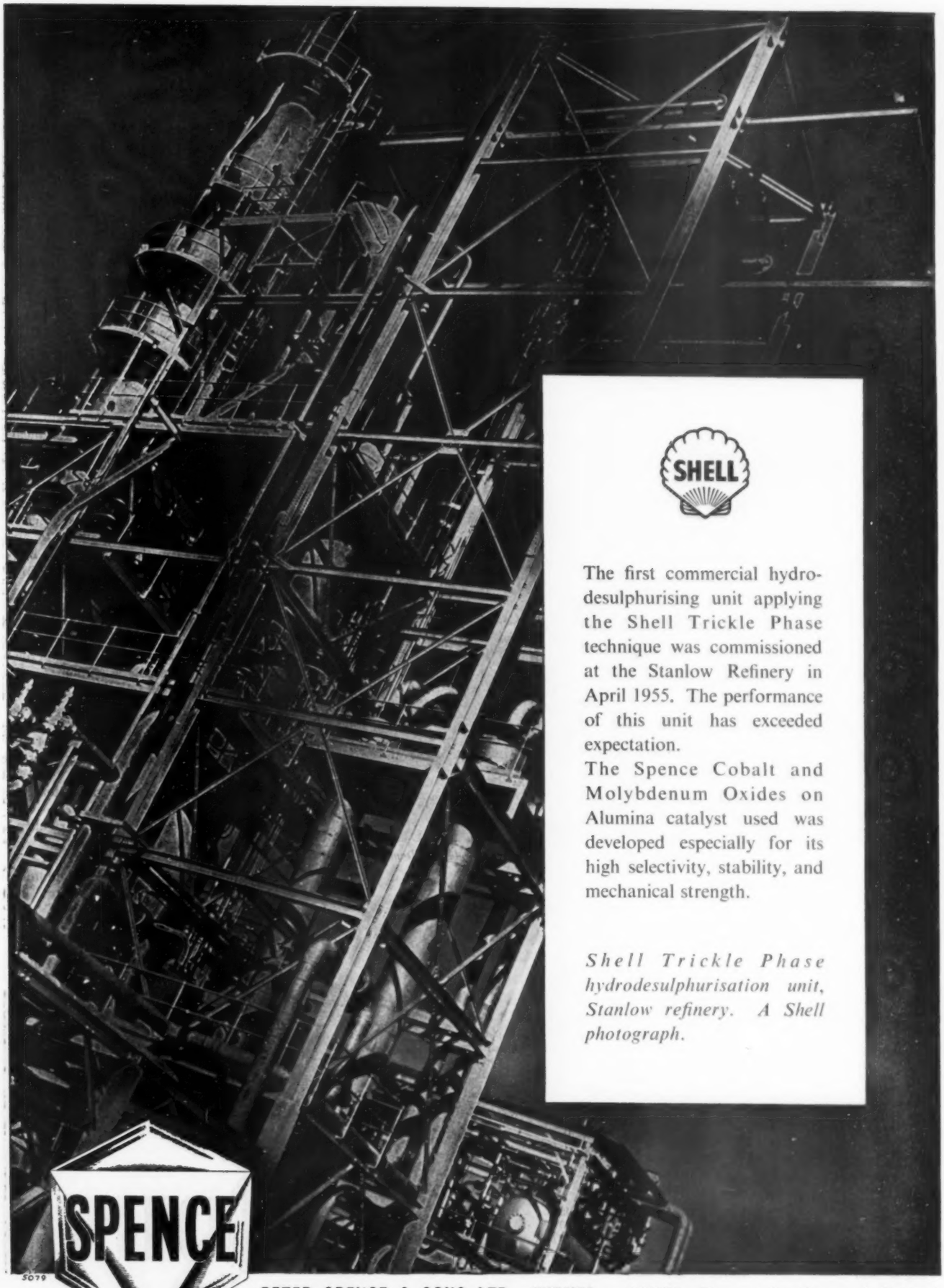
	1955	1956	% Change
Gasoline	1,480	1,700	+14.9
Jet fuel and kerosine	817	590	—27.7
Gas and diesel oil	1,613	1,830	+13.4
Residual fuel	1,713	1,440	—15.9
Lubricants	—	—	—

The Italian natural-gas industry also enjoyed a record year in 1956. Production rose 25%, to 4.7 billion cubic meters. Natural-gas consumption increase is mainly due to domestic heating (+38%) and to construction and metal industries (+28% and +26%). Largest volume consumers of natural gas are the chemical (20% of the total consumption) and metallurgical (18%) industries and the thermoelectric power stations (15%).

Petrochemical activities continued to expand at the Montecatini works in Ferrara (where imported crude oil is used as the raw material) and in Novara (where natural gas is used). Increased quantities were produced of ammonia, nitric acid, nitrogen fertilizers, formaldehyde, acetylene, polymers, oxo-compounds, etc. Other minor concerns have continued the production of acetylene, vinyl derivatives, and other natural-gas chemicals.

The erection of the ANIC-ENI synthetic-rubber and fertilizer plants from natural gas at Ravenna is actively progressing. The whole group of units should start operations before the end of 1958. Koppers International recently announced that a styrene monomer plant will be erected there. Capacity will be 14,000 tons per year.

Petrochemical programs are being stud-



SHELL

The first commercial hydro-desulphurising unit applying the Shell Trickle Phase technique was commissioned at the Stanlow Refinery in April 1955. The performance of this unit has exceeded expectation.

The Spence Cobalt and Molybdenum Oxides on Alumina catalyst used was developed especially for its high selectivity, stability, and mechanical strength.

Shell Trickle Phase hydrodesulphurisation unit, Stanlow refinery. A Shell photograph.

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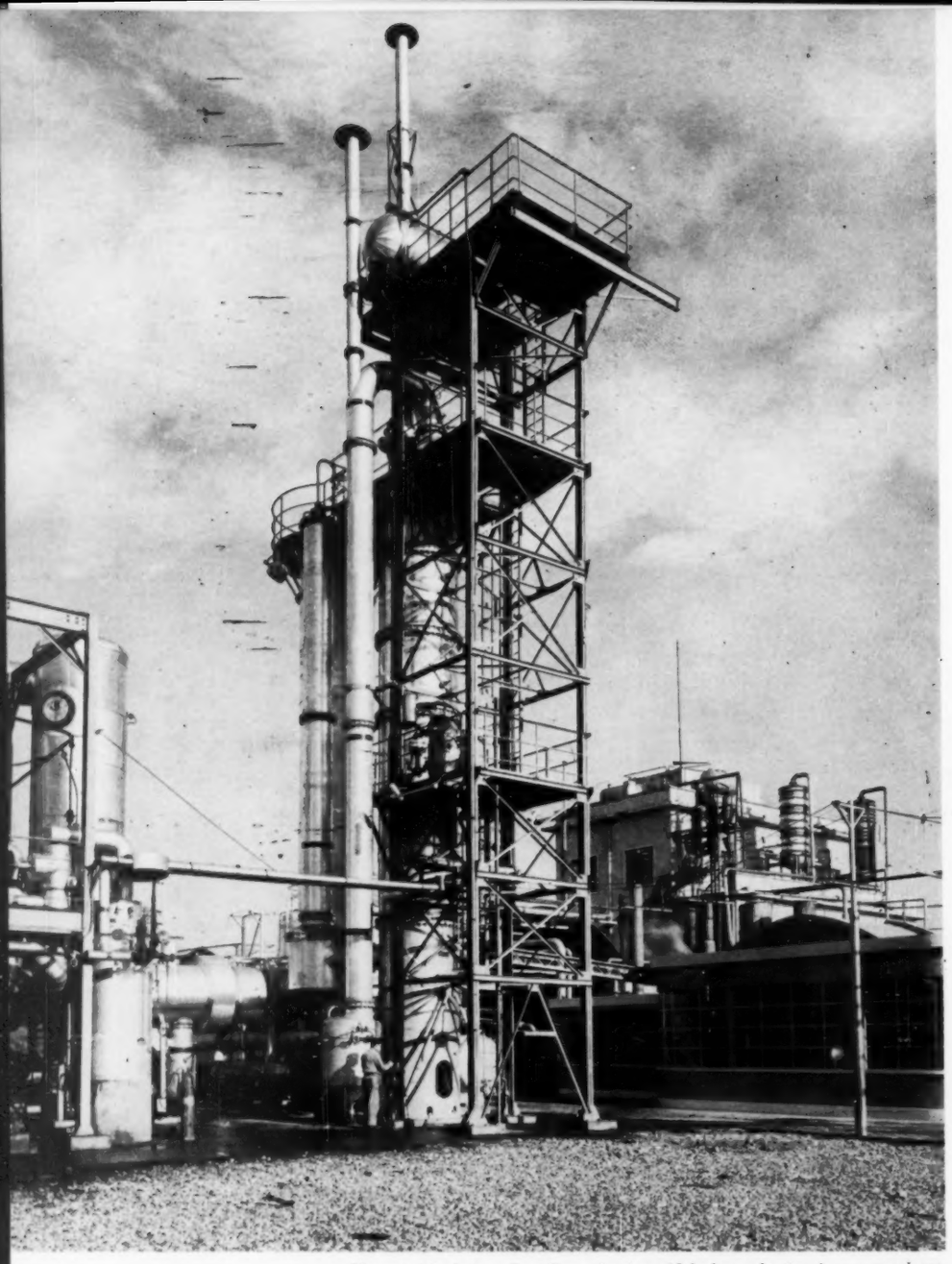


Montecatini plant at Castellanza for formaldehyde production from natural gas.

ied also by the Edison Co.; petrochemical plants of undisclosed size and scope are planned at the Mantua works presently under construction.

Main event of the year in the Italian petrochemical industry was the announcement by Montecatini of the commercial production of a new polypropylene plastic "Moplen." Developed by a team of researchers at the Institute of Chemical Engineering of the Politecnico of Milan, under the direction of Professor Giulio Natta, the new product is characterized by structural regularities (isotactic polymer) which impart its peculiar qualities. The isotactic polymers are produced using special catalysts, so-called stereospecific, which promote the formation of spatially ordered structures in the polymerization of olefins.

Polypropylene was one of the first products investigated for commercial production. Other olefins have also been studied, and the results of research in this field have been published in the chemical press in Italy and abroad.

The present production of "Moplen" (trade name under which Montecatini is marketing the commercial propylene polymers) at the Ferrara works, is close to 5 tons per day, to be increased to about 20 tons per day in the near future. Moplen is produced in two different types: Moplen/1 and Moplen/2, differing in molecular weight and processing properties. Moplen/1, of relatively low molecular weight, has a low viscosity when melted, and is particularly suitable for extrusion of films and for blow-molding of containers. Moplen/2, of higher molecular weight, can be molded by injection, and extruded with conventional machinery.

Among the basic properties of the new polymers is high thermal stability, much higher than for any other thermoplastic material (Moplen withstands temperatures above 150 C), low density, relatively high yield point, high flexional rigidity, good shock resistance, and excellent chemical resistance.

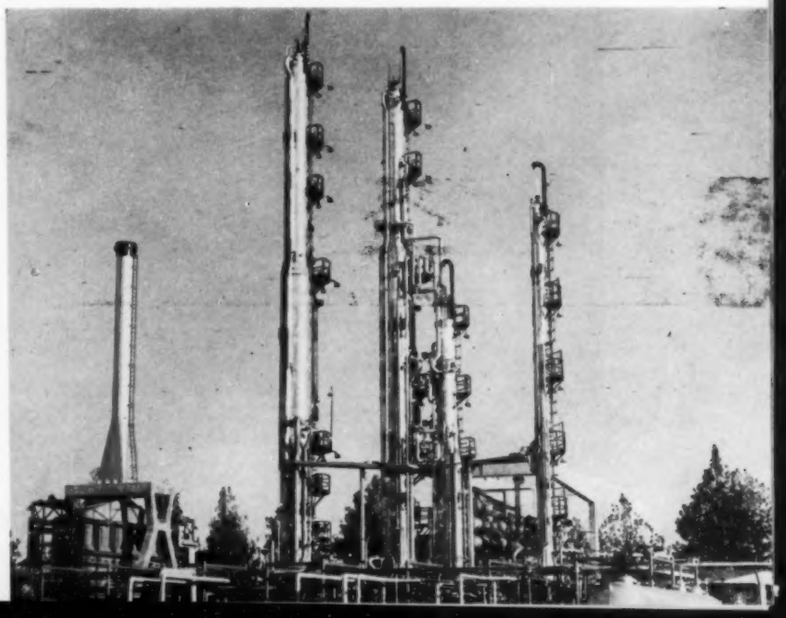
The main properties of Montecatini's polypropylenes are reported in Table IV.

END

TABLE IV
PROPERTIES OF NEW "ISOTACTIC" POLYPROPYLENES (MOPLEN)

Property	Unit	Test Method	Moplen/1	Moplen/2
Specific gravity —	kg/l	ASTM D-792	0,90—0,91	0,90—0,91
Specific volume	l/kg	" D-792	1.100	1.100
Apparent density (granular form)	kg/l	" D-392	0.400	0.400
Tensile breaking load	kg/cm^2	" D-638	300— 350	320— 360
Elongation to breaking	%	" D-638	500— 700	500— 700
Stiffness	kg/cm^2	" D-790	9,000—12,000	8,000—10,000
Izod resiliency (unnotched specimen)	kg/cm/cm^2	" D-256	>80	>80
Resistance to compression	kg/cm^2	" 695	600— 700	600— 700
Rockwell hardness	R scale	" 785	90— 95	85— 90
Melting temperature	deg C	crystallographic	164— 170	164— 170
Thermal conductivity	cal/sec cm^2/cm/deg C	ASTM D-570	3.3×10^{-4}	3.3×10^{-4}
Linear dilatation coefficient		" D-696	110×10^{-6}	110×10^{-6}
Viscat softening point	deg C	DIN 57302	105— 110	100— 105
Maximum temperature in use (no strain present)	deg C	——	150	150
Bulk resistivity	ohm/cm	ASTM D-257	$>8 \times 10^{15}$	$>8 \times 10^{15}$
Dielectric rigidity	kV/mm	" D-495	30— 32	30— 32

Visbreaking unit at the SAROM refinery at Ravenna.



Tray supports being fitted to secondary column of the No. 2 distillation unit at BP Kent refinery (BP photo).

by E. Lawson Lomax

BRITISH REFINERY THROUGHPUT

rises 8.5% in 1956 despite Suez crisis

REFINERY operations in the United Kingdom rose to a record figure of 28,681,263 tons (573,600 b/d) in 1956, an increase of 8.5%. The figure would have been still higher if it had not been for the Suez Canal crisis, which caused a reduction of some 320,000 tons in refining throughput in the last three months of 1956, compared with the same period in 1955. The following tabulation, based on data published by Petroleum Information Bureau, shows the refinery production figures for the year 1955 and 1956, in tons:

Products	*1955*	*1956*
Motor and aviation gasoline	6,874,706	6,771,195
Industrial spirits	2,460	2,291
White spirit	134,614	133,926
Burning oil	707,243	771,330
Vaporizing oil	95,375	98,037
Gas-diesel oil	4,584,549	5,188,849
Fuel oil	10,319,596	10,394,848
Refinery-fuel consumption	2,035,365	2,130,906
Bitumen	851,075	933,432
Paraffin-wax scale and slack wax	18,041	19,326
Lubricating oil	706,318	776,385
Propane and butane	57,875	66,260
Miscellaneous products and loss	1,210,653	1,394,478
	27,597,871	28,681,263

There was an increase in all products in 1956, except in the case of gasolines, industrial spirits, and white spirit. Although production of these items decreased, consumption was higher—comparative bulk figures for these products being: produced, 6,907,412 tons; consumed, 8,381,314 tons. The consumption includes some 402,000 tons of spirits made from coal, and also some imported aviation gasolines. The consumption of motor gasoline was only 1.3% higher than in 1955. This was due to rationing in the last quarter, causing a fall of 1.2%. Again in 1956, the consumption of premium grades of gasoline increased, while that of standard gasoline decreased.

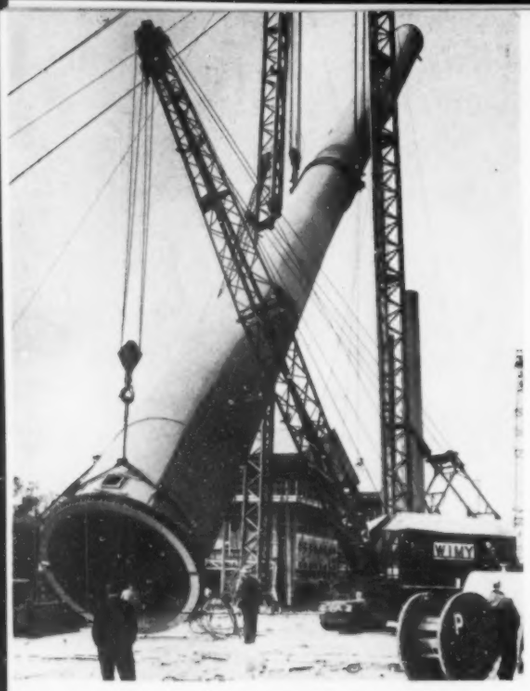
The increasing use of diesel road vehicles also affected the consumption of standard gasoline for large vehicles—the deliveries of DERV increasing by about 12% over 1955, the increase in production being about the same order, i.e., 13%.

The demand for kerosine continually increases; part of this increase is due to its growing use for domestic heating, and part for the use as jet fuel.

The production of fuel oils showed little increase due to the fact that new distillation units projected for increasing production of heavy residues are not yet in commission.

An interesting increase is that of bitumen. Annual production of asphalt is now near the million-ton-per-year mark, and indicates in a way the increasing tempo of road building in Britain. There is plenty of room for a much more vigorous program in that direction.

Production of lube oils increased by about 10%; and, as the consumption only rose 1%, this indicates that UK refineries



Lifting 250-ft-long chimney for new distillation unit as a part of £26,000,000 expansion program at British Petroleum Co.'s Kent refinery: Chimney weighs 94 tons; is 10 ft in diameter. It was lifted into position by two diesel winches (BP photo).

are continuing to reduce the amount of lubricants imported from other countries.

The home consumption of petroleum products—not including similar products from coal, but including refinery fuel—was 24,821,049 tons, while the net refinery production, allowing for refining losses, was 27,286,785 tons, leaving a margin of nearly 2.5 million tons for export, a large amount of which goes to the Scandinavian countries.

The refinery capacity in the UK at the end of 1956 was in the neighborhood of 30 million tons per year; but, with the addition of new plants now building and with reorganization of existing plants, this capacity by early 1958 will be increased to over 42 million tons per year, a total which was never envisaged when the postwar program of development was started.

While only one new refinery is projected —and that in Eire—a large amount of expansion work is being carried out in the UK refineries—the plant which is in course of installation being mainly such as will increase the production of heavy residues, with a lesser increase in the production of white oils, as the demand for the former is increasing at a greater rate than the latter.

The new Irish refinery is a modification of a scheme which was developed in 1935, at the instigation of the Irish government, but which later was abandoned owing to financial considerations. The government of Eire, was anxious to establish a domestic refining industry. At first, the industry was to be run by the operating company, which would gradually establish a complete staff of Irish nationals to take charge of all operations, and at the end of an agreed period the government should have the option of taking over the whole enterprise.

For the present enterprise, a working committee representing The California Texas Corp., Esso Petroleum Co. Ltd., and Shell-Mex and BP Ltd. has been formed which will carry out the building and operating program. Chairman of this committee is N. P. Briggs; and Dr. R. R. Lawton, formerly a director of Soc. Mid. BP Belge, Antwerp, has been designated manager. The committee was formed at the request of the Irish government; and Dr. Beddy, chairman of the Independent Development Assn., Dublin, has been very active in the negotiations. A new company, registered in the Republic of Ireland to own and operate the refinery, is in course of formation.

The site chosen for the new refinery is a plot of 1,400 acres in the Whitegate area of County Cork, at the seaward end of Cobh harbor. The refinery will be built on the mainland, but the storage tanks will be located on Cork Beg Island, which is joined to the mainland by a narrow isthmus. A jetty is to be built on Cork Beg Island where the depth of water is sufficient to accommodate the largest projected ocean-going tankers. This jetty will also serve to load barges and local coastal craft for distribution of products. There is no railway accommodation to the refinery site, so products not distributed by sea will be distributed by over-the-road transport.

The capacity of the refinery, which is to be engineered by the Lummus Co., is 40,000 b/d (about two million tons per year).

The main crude atmospheric distillation unit is being built in combination with a desulfurization unit so that gas oil, which requires desulfurization, may pass directly through, alternatively; where desulfurization is not required, it may be bypassed to storage.

Overhead incondensible gases will be taken off—with gasoline, naptha, kerosine, and gas oil sidestreams. The naptha stream will be treated in a catalytic reformer—this being the only cracking type of operation in the plant; and the reformed spirit will be blended with the straight-run to raise the octane number. The hydrogen from this reforming unit will be used in the desulfurization unit.

The kerosine fraction will not be treated for domestic use, but will go for jet fuel. Kerosine required for lighting and heating domestically will be imported. The C_3 and C_4 incondensible gases will be used and sold as bottled gas.

In addition, other products, such as lube oils, waxes, etc., will be imported by the committee companies according to their requirements. Other products for sale will be drawn from the refinery production.

The land on which the refinery is to be built stands about 200 ft above sea level, and is of such design that no piling will be required for foundations. A unique feature of the refinery is that the major portion of the plant will be air-cooled, so that little or no condensing water will be required.

Arrangements have been made with the local county council for the supply of fresh water for steam raising, which will be used only for process, as power will be drawn from the Irish Grid. Erection is due to commence in a few months, and the refinery is scheduled for completion by the middle of 1959.

As much as possible of the material for building the refinery is to be purchased in Eire; and, when production commences, an Irish staff is to be employed as much as possible—with a view, eventually, of a completely Irish staff. With this end in view, Irish nationals are already being trained in the refineries of the companies forming the committee.

Construction work is well under way in the major £26 million expansion schemes for increasing the present capacity of the British Petroleum Co.'s Isle of Grain refinery by about 90,000 b/d. The schemes also embody a specialist plant for aviation-gasoline production.

The crude-distillation unit, 90,000 b/sd, including soda washery and other auxiliary units, is to be to the designs of E. B. Badger & Co.

A thermal reformer of 12,000 b/sd and a Platformer of 10,000 b/sd are being installed —the engineering being in the hands of Kellogg International, in conjunction with Universal Oil Products in the case of the Platformer. The same firm is also responsible for the erection of two Hydrofiner units each of 10,000 b/sd capacity. An alkylate plant, with a capacity of 2,250 b/sd of aviation-gasoline constituents, is being installed, and is being engineered by Lummus. Although this process was developed in the UK by the then Anglo-Iranian Oil Co. and units were erected and operated during the war in Abadan, this is the first unit to be erected in the United Kingdom.

One 12,000 b/sd stabilizer built by the Power Gas Corp. is being installed.

For treating of the light distillates, two solutizer plants of 2,000 b/sd each and two copper-chloride units of 8,000 b/sd each are to be installed—the contractors for these units being W. J. Fraser & Co.

The whole of this new plant is scheduled to come onstream early in 1958.

These extensions involve increases in the capacities for steam raising, electric power, cooling water, and effluent disposal. The main contractors for erection work are Wimpeys, and for civil engineering Sir Robert-McAlpine & Co.

Power Gas Co. and W. J. Fraser Ltd. are joint contractors for the engineering of the offsite facilities.

Along with the refinery extensions, two new jetties are being built on the River Medway which will be capable of berthing the largest projected supertankers with full incoming crude cargoes. Rendall, Palmer & Tritton are the consulting engineers for the jetties.

Additional to these extensions in the refinery, is the large catalytic oil-gasification plant, which is being built in close proximity to the refinery by the South Eastern Gas Board, into whose distribution system the cracked gas will be fed.

Subject to British parliamentary ap-

proval, a new crude-oil tanker terminal and tank farm is to be built at Popton Point on the south shore of Milford Haven, Pembrokeshire. This terminal and tank farm will be connected with the British Petroleum refinery at Llandarcy by a 60-mile buried pipeline with a capacity of 100,000 b/d of crude. Two new jetties are to be built, each capable of accommodating the largest tankers. Vessels would discharge direct by their own pumps to tank storage 1½ miles away. A main electrically-operated pumping station would then pump the crude to Llandarcy.

The annual capacity of the Grangemouth refinery is to be raised by nearly 20,000 b/d by the replacement of a crude still and by a new and larger distillation unit. Auxiliary refining units are to be added, as well as extra tankage and other facilities.

The refinery's new increased capacity will be 62,000 b/d, which is approximately equal to the annual carrying capacity of the 57-mile pipeline from Loch Finnart to Grangemouth. At Finnart, a new jetty capable of accommodating the largest tankers is to be built.

The new jetty is scheduled for completion at the end of 1958, and the refinery extensions in 1959.

Capacity of the Fawley refinery of Esso Petroleum Co. Ltd. is being increased to 210,000 b/d from 140,000 b/d (to 10.5 million tons per annum from 7 million tons), by the addition of a third 70,000 b/d crude-distillation unit which is scheduled for completion in January 1958.

Two more Hydrofiner units are being installed for the hydrodesulfurizing of certain products; the first of these two units came onstream in January this year, and the second is scheduled for commissioning June 1957. A new sulfur-recovery unit, similar to the existing one, is under construction to raise the recovery of sulfur to 28,000 tons a year.

The contractors for the whole of the foregoing units are Foster Wheeler Ltd.

As a necessary corollary to the above extensions is a new 200,000-lb-per-hour steam boiler now under construction by Babcock and Wilcox Ltd.

Whescoe Ltd. and Motherwell Bridge & Engineering Co. are engaged on a continuous program of tankage construction both for crude oil and finished products.

At the marine terminal, extra berthing facilities are being installed by John Mowlem & Co. Ltd.

Subject to parliamentary approval and to local agreement, Esso contemplates building another refinery on the land purchased at Milford Haven.

The Coryton refinery of Mobil Oil Co. Ltd. averaged a larger throughput in 1956 than in previous years. However, the running of the refinery was affected by the Suez crisis. The TCC catalytic cracking unit was shut down to assist in increasing fuel-oil production at the expense of gasoline, and the start of the 6,000 b/d catalytic reformer was delayed. This had been completed by Bechtel International Ltd. in the autumn.

The new tanker jetty came into use in autumn 1956, using the new hose-handling system in which the hoses are wound on 18-ft-diameter reels.

Modifications made to the crude-distillation unit will enable the throughput to be raised to 35,000 b/d from 30,000 b/d.

A new technical service laboratory, built alongside the refinery, is practically completed, and will be in service by the time this appears in print.

No major additions have been made at Shell's Stanlow refinery since 1956. Modifications of existing plants are in progress with the object of further increasing processing capacity.

At the Shell Haven refinery, a new crude-oil distillation unit with a capacity of 80,000 b/d is in course of construction, and is scheduled for completion in the third quarter of 1958.

The addition of this unit will more than double the distillation capacity of this refinery—raising it to 155,000 b/d from 75,000 b/d (i.e., to 7.75 million tons per annum from 3.75 million). The erection of this plant entails increases in auxiliary services, and also increases the refinery capacity for fuel-oil production. A catalytic reformer of 6,700 b/sd has been erected and started.

At the Heysham and Ardrossan refineries, no alterations have been made during the year.

During the past year a Platformer with a design capacity of 800 b/d has been erected by Lobitos Oilfield Ltd., and was put into commission in April 1957. When this unit is working on Middle East crude and not on sweet Peruvian crude—which is now the main crude used—a gas-treating unit has to be employed to desulfurize it. Later, this Platformer may be run under more severe conditions for the production of highly aromatic stock.

A sulfonate plant is under construction and due for completion in the early autumn of this year. The plant will use gaseous sulfur trioxide for the sulfonation of a lube-oil cut which has previously had a preliminary treatment by the Edeleanu process and sulfuric acid. The intention is to produce both calcium and sodium sulfonates as lube-oil additives. The capacity of the plant is 3,500 tons per year.

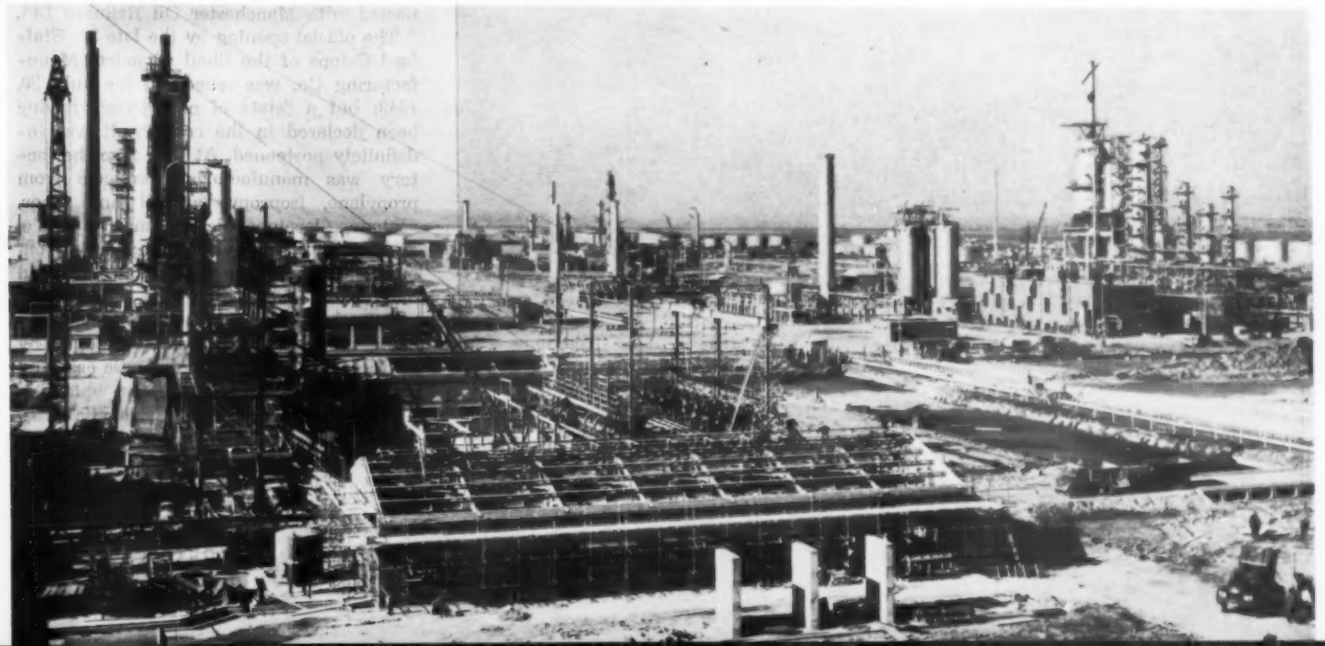
A new atmospheric and vacuum unit is to be erected by Berry Wiggins & Co. Ltd., at its Weaste refinery, with a capacity of 1,600 b/d. This unit is scheduled for completion late in 1957 or early 1958; and, although erected mainly for the production of bitumen, a full range of products will be made from crude oil.

No major additions have been made by Manchester Oil Refinery Ltd. during the past year to the distillation and solvent-extraction plant.

Improvements have been made in the white-oils plant, and this new plant is undergoing trial runs.

The plant erected in 1955 for the manufacture of alkyl pyridines has been increased in capacity by the installation of additional distillation equipment. END

General view of construction work at No. 2 distillation unit area at BP Kent refinery: Catalytic cracker unit is at extreme right (BP photo).

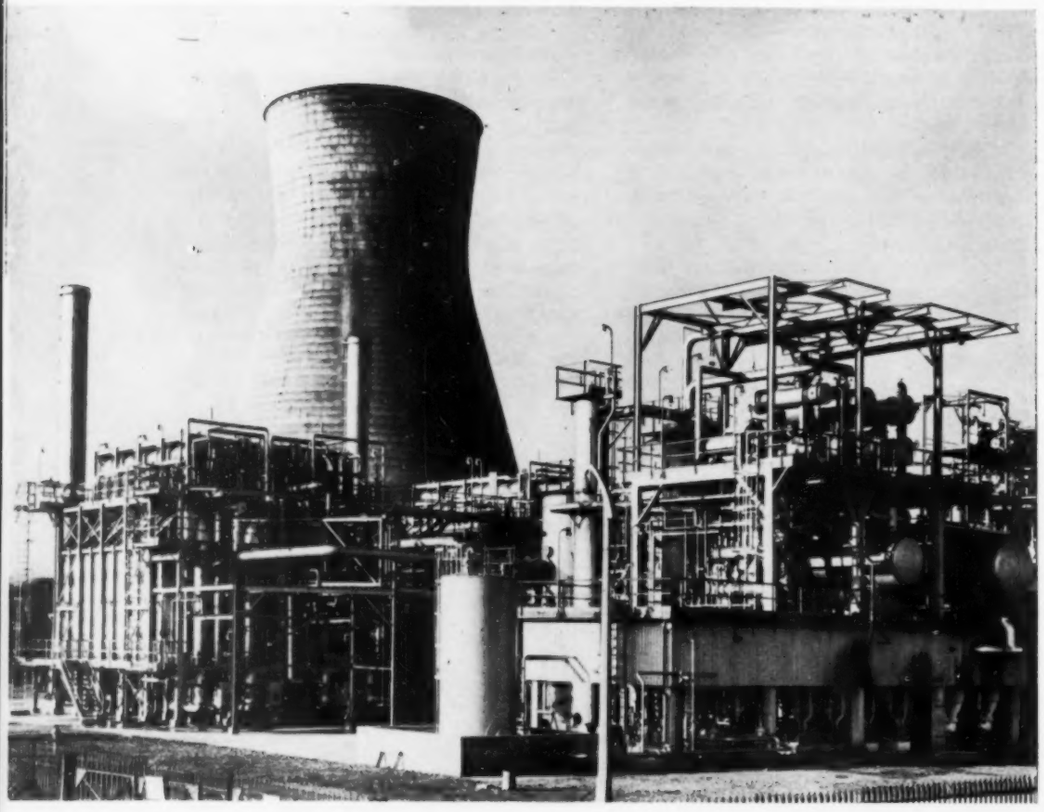


PETROCHEMICALS IN THE UK

by E. Lawson Lomax

Culminating eight years of development, the British petrochemicals industry will produce 900,000 tons of products in 1958. A wide variety of intermediates now are produced in volume for plastics, paints, and other industries.

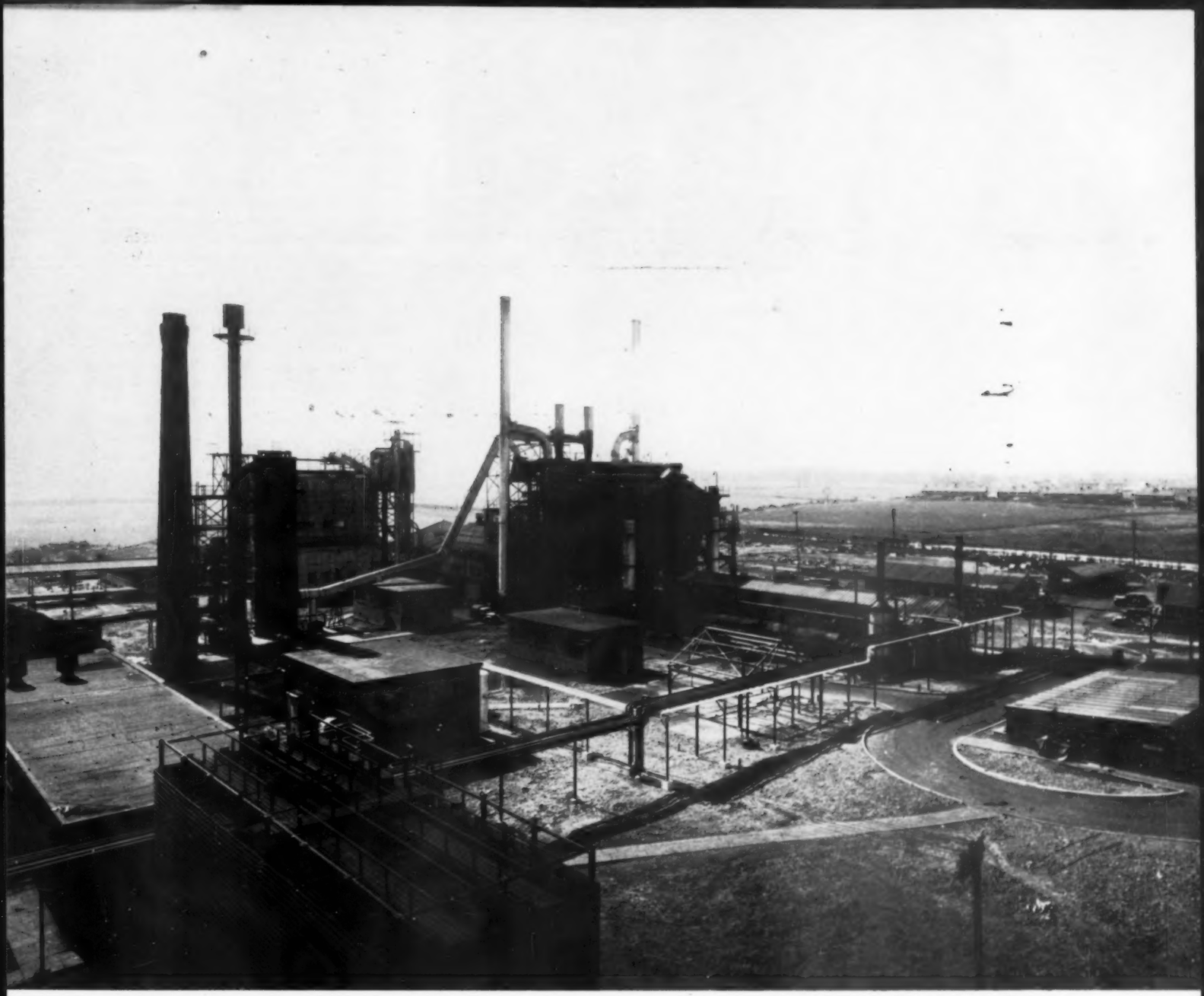
No. 2 ethylene plant of British Hydrocarbon Chemicals Ltd. (BP photo).



DEVELOPMENT of the petrochemicals industry in the United Kingdom has largely taken place in the past eight years. Prior to that time there was very little production in the UK, although petroleum products made by chemical action, such as detergents and salts of napthenic acids, were on the market. On the other hand, many schemes had been worked out for the synthesis of petrochemicals from petroleum gases, and several plants for this purpose were under construction. Two plants were operating for the manufacture of chemicals from the products of petroleum cracking, i.e., the Shell group's plant, located near the Stanlow refinery, from which it drew its raw materials; and the plant of Petrochemicals Ltd. at Partington, Lancashire, the company at that time being closely connected with Manchester Oil Refinery Ltd.

The official opening by the late Sir Stafford Cripps of the Shell Chemical Manufacturing Co. was scheduled for July 20, 1949; but a "state of emergency" having been declared in the country, it was indefinitely postponed. At that time the factory was manufacturing products from propylene, isopropyl alcohol and ether, acetone, diacetone alcohol, mesityl oxide, and methyl isobutyl ketone; and, from butylene, secondary butyl alcohol and methyl ethyl ketone.

Petrochemicals Ltd., at Partington, was using the Caterole process, developed by Petrocarbon Ltd. for the catalytic cracking of certain petroleum distillates—obtaining liquid products of mainly aromatic type,



General view of Cabot Carbon's carbon-black plant.

and uncondensible gases which were fractionally separated by distillation under pressure into more or less pure single hydrocarbons, these being subsequently employed in the manufacture of derivatives.

Later Petrochemicals Ltd. got into severe financial and technical difficulties, and in July 1955 was taken over by the Shell group, which is now operating it under its original name.

In 1951 the Grangemouth plant of British Petroleum Chemicals Ltd. (now British Hydrocarbon Chemicals Ltd.) came into operation. The plant used, as raw stock, a petroleum spirit supplied by the Grangemouth refinery—the main products being ethylene and propylene, which were converted into ethyl and isopropyl alcohols. This plant has been considerably increased in capacity since its opening, and also further processes have been installed in adjacent works built for this purpose.

The furnace carbon-black plant at Philblack Ltd. in South Wales was officially opened in October 1951; and that of Cabot-Carbon Ltd., at Ellesmere Port, was opened earlier the same year.

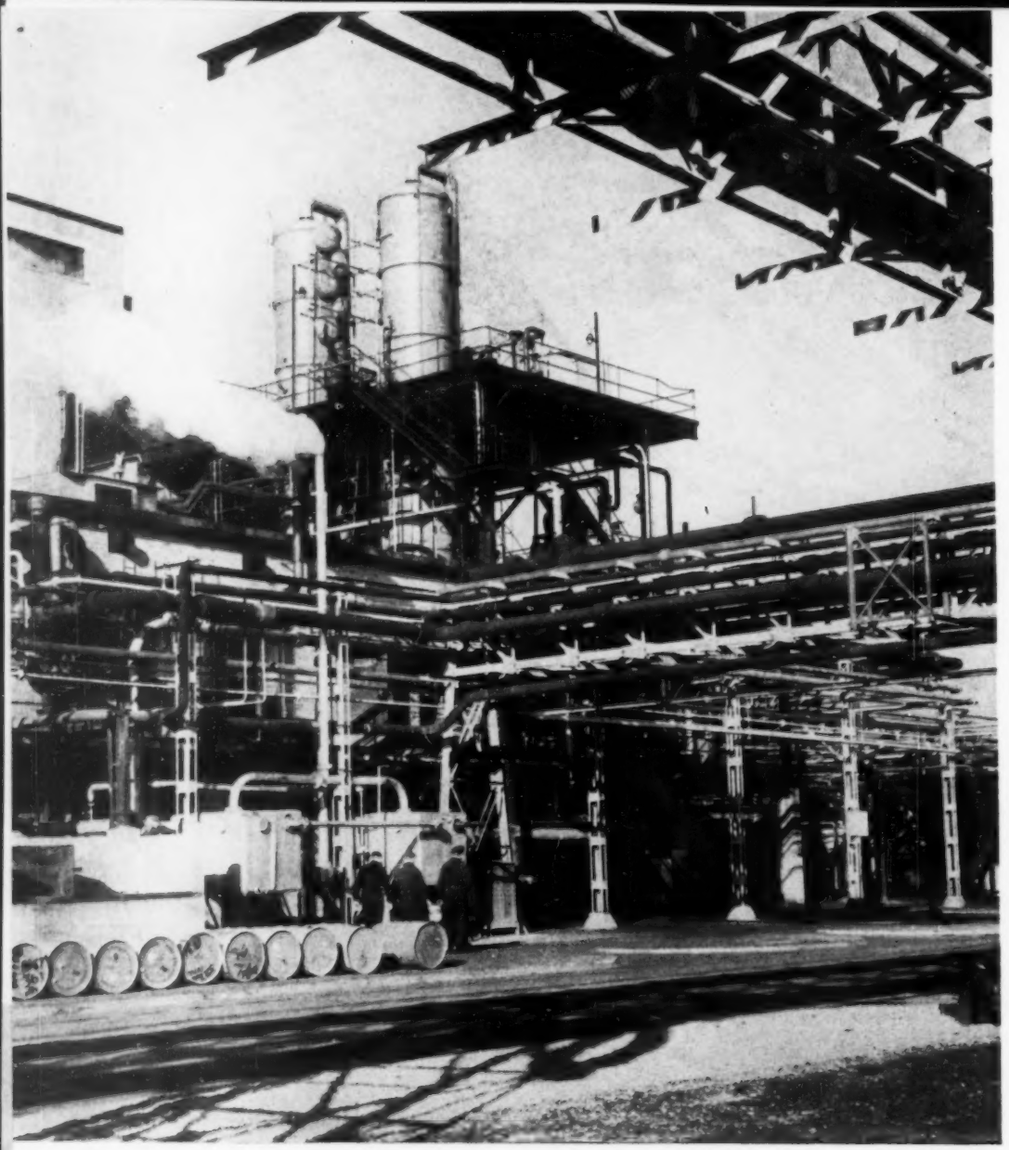
Other plants for the production of petroleum-based chemicals have been brought into operation in the past eight years with the Shell refinery extension at Shell Haven, the group of plants built adjacent to British Hydrocarbon Chemicals plant at Grangemouth, the butadiene plant at Esso's Fawley refinery, and the nearby butyl rubber plant of the International Synthetic Rubber Co.

Another petrochemical plant in a slightly different category is that of Imperial Chemical Industries, where cracking plants have been erected, especially for the production of unsaturated hydrocarbons from a selected petroleum distillate. The gaseous products are utilized in the manufacture of a considerable number of chemical compounds and plastic products.

British Hydrocarbon Chemicals Ltd. was originally formed by Anglo-Iranian Oil Co. and the Distillers Co. Ltd. as British Petroleum Chemicals Ltd., the present name being adopted in 1956. The two companies pooled their knowledge and also the good will of the Distillers Co. which had previously been making synthetic organic chemicals, using molasses as a raw stock.

The first plant comprised a cracking unit and a gas separation unit. It was erected adjacent to the Grangemouth refinery of the British Petroleum Co. Ltd., which supplied the petroleum fraction for cracking to gaseous olefins; the first products made were mainly ethyl and iso-propyl alcohols.

The next step was the formation of Forth Chemicals Ltd., in 1950, by British Petroleum Chemicals and Monsanto Chemicals Ltd., Monsanto holding a third of the rights. This company manufactures monomeric



Alkyl benzene plant at Newport works of Monsanto Chemicals Ltd. (Monsanto photo).

styrene, an intermediate for the production of polystyrene. A plant was erected on a site adjacent to that of BHC and commissioned in 1953. In 1956 the capacity of this plant was trebled.

In 1955, a third company was added to the group, i.e., Grange Chemicals Ltd., which is two-thirds owned by BHC and one-third by Oronite Chemical, a subsidiary of Standard Oil Co. of California. A plant was erected within the BHC's area for the production of dodecyl benzene, an intermediate in the manufacture of synthetic solid detergents. The plant was commissioned in 1956. In order to meet the needs of these associates and to satisfy other demand, BHC, in 1956, embarked on a major expansion program involving the provision of a second cracking and gas separation plant, the duplication of the ethanol plant, a propylene tertramer unit to supply the raw material for Grange Chemicals, and a butadiene plant to extract this unsaturated hydrocarbon from the cracker gas for butyl rubber production.

A portion of the ethylene from the new cracker will be sold to Union Carbide Ltd. as raw material from a high-pressure polyethylene plant to be erected by Gemec Ltd. on a site close to BHC's main plants.

Since the commissioning of the BHC's plants in 1956, it has been announced that the company has purchased part of the site of the disused Grangemouth aerodrome where it will erect a plant to produce polyethylene by the Phillips low-pressure process. BHC's works now cover an area of about 120 acres, and employs some 1,000 persons.

Total investment by British Hydrocarbon Chemicals, including its share in subsidiary companies, now amounts to some £16 million.

The Shell group of companies operates production units at the Stanlow and Shell Haven refineries and the Partington plant of Petrochemicals Ltd. Selling organization of the group is Shell Chemical Co.

The works at Partington, which were purchased by Shell Chemical Co. in 1955, cover about 120 acres, with some 500 more acres available for development. The basic process employed is the high-temperature vapor-phase cracking of a light naphtha distillate from Middle East crudes by the "Catarole" process developed by Dr. Weizmann, the late president of Israel. A liquid is produced with a high aromatic content with gaseous olefins. Products are similar to those by the Ritmann process in the USA in 1917 and the contemporary Hall process in the UK—the cracking temperature in all cases being about the same, i.e., about 700 C. At this temperature, a large amount of coke is formed and the mechanical strength of the furnace tubes is very low, so only very low pressures are employed.

Vaporized oil from the cracking furnace passes first through the pitch pots where heavy tars are deposited and then to the cooling system for the separation of the liquids from the gases. Uncondensed gases are desulfurized and then are separated into their constituent parts in the gas separation plant by refrigeration compression, and fractionation at low temperatures. The saturated and uncondensible gases not required for further processing are sold to the local gas works for enriching the standard coal gas—some 2 mmcf per day being thus disposed of.

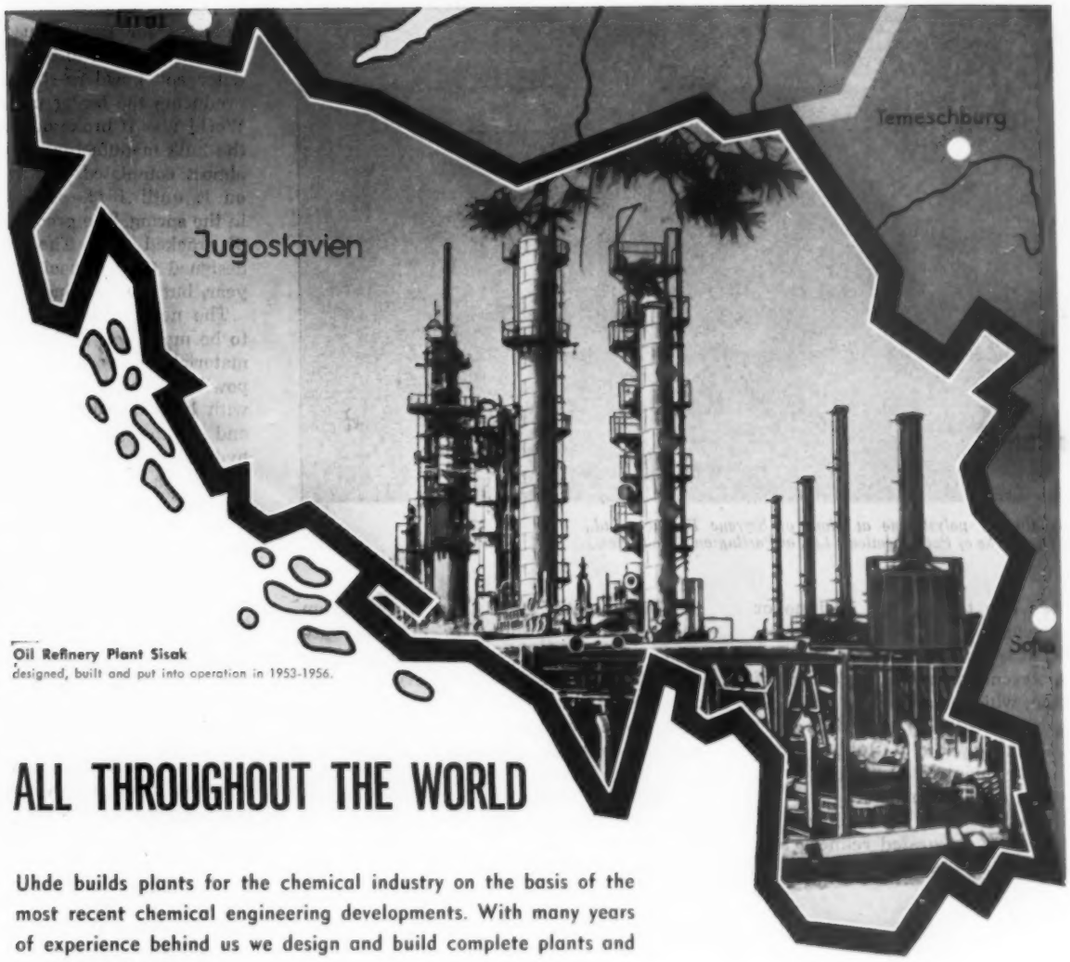
Polyethene is used for the production of isopropyl alcohol by the usual reaction with sulfuric acid, followed by hydrolysis and subsequent purification by distillation.

Ethylene is used for the manufacture of ethylene oxide via ethylene chlorohydrin—the oxide thus produced being further used in the manufacture of ethylene glycol, ethylene glycol ether, and ethanolamines. A certain amount of propylene oxide is manufactured by the same process, and forms the basic material of a number of derivatives. Work is in hand for the production of these oxides by direct air oxidation of the olefins, using a process developed in the USA. The plant is scheduled to go into production in 1958.

Aromatic condensates at Partington are fractionated into four main products, viz., crude benzene, toluene, a mixture of xylenes, and styrene and still bottoms. The nonaromatic contents of the benzene and toluene fraction are removed by azeotropic distillation, giving pure benzene, and toluenes. The xylostyrene fraction is used in the production of styrenated alkyds and oils for paint formulation.

Styrene Products Ltd., a wholly owned subsidiary of Petrochemicals Ltd., in its Partington plant produces polystyrene molding powders to customer requirements. Monomer styrene is received by rail car, and is polymerized to polystyrene by the "bead process"; the beads are colored by dye mixes, heated to spread color evenly, and extruded to ribbons which are then chopped to granules for sale to molding firms. In addition, detergents of the nonionic type are produced. New projected developments are styrene-acrylonitrile, which has great impact strength and resists staining by gasoline and fruit juices, and expanded polystyrene which will be used as an insulating medium.

Petrochemical Ltd. holds the sole license for the manufacture of Ziegler polyethylenes in the UK, and a semicommercial plant for the manufacture of this low-pressure poly-



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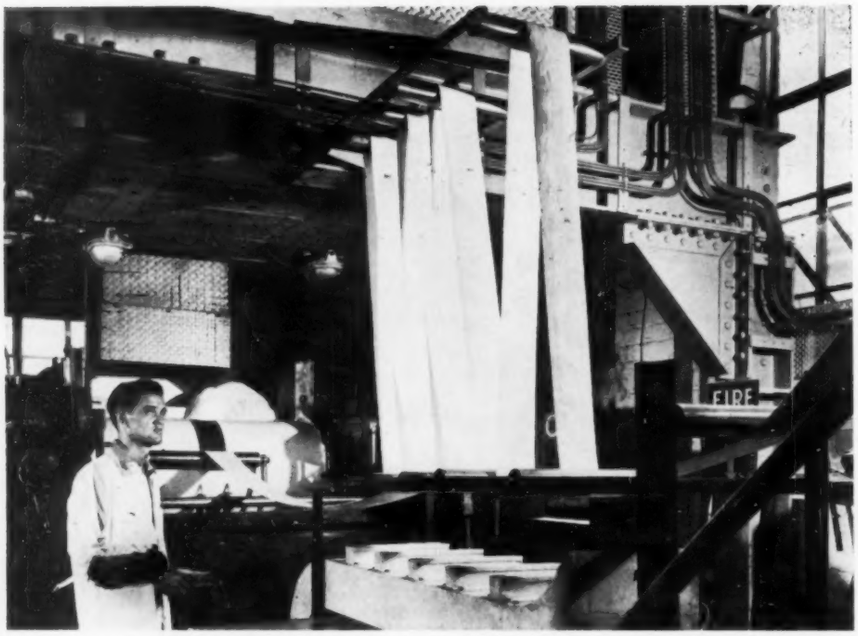


Mill compounding of polystyrene at plant of Styrene Products Ltd., adjacent to main works of Petrochemicals Ltd. at Partington (Shell photo).

ethylene was due to start up in June or July of this year.

A new plant is being erected for the production of styrene monomer, at a cost of £1.75 million, which is scheduled for commission during 1958. This plant will supply the International Synthetic Rubber Consortium's Fawley plant with styrene for the manufacture of synthetic rubber.

The Shell Co.'s refinery at Stanlow is an example of a fully integrated refinery and chemical plant within one boundary fence, in which practically all types of petroleum products from gasoline to bitumens are made. Many petrochemicals are made from streams produced in the ordinary course of oil refining, and petrochemicals are made using pure gaseous hydrocarbons as raw products. Among the varied list may be mentioned elemental sulfur. All the crudes handled are sour, and Stanlow recovers practically all the sulfur in the crudes and, as a result, keeps its acid plant fully supplied and has available for sale about 15,000 tons per year of elemental sulfur. Naphthenic acid and sodium naphthenates are separated from the crude oil during the course of refining.

Shell claims to supply nearly two-thirds of the synthetic detergents used directly by industry for process use and more than half the supplies to the makers of domestic detergent powders—the Stanlow refinery producing the larger portion of this. When World War II broke out in 1939, a plant for the bulk manufacture of alkyl sulfates was almost completed, but work was held up on it until 1942—production commencing in the spring. The process is the sulfonation of cracked wax. The original plant was designed for a capacity of 10,000 tons per year, but now produces 50,000 tons.

The next product in this detergent line to be made was an alkyl benzene, the raw material for the manufacture of detergent powders. This is a polymer of propylene with benzene carried out under pressure, and in the presence of a catalyst. Anhydrous aluminum chloride or fluoride and anhydrous hydrofluoric acid have been mentioned as catalysts for this process.

The resulting product is separated by fractionation—the objective being a pure dodecyl benzene, if possible. The incondensible gases produced in the various cracking and reforming plants are handled together in the gas separation unit—where, after being desulfurized, they are fractionated into their various constituents for use as raw products in petrochemical manufacture.

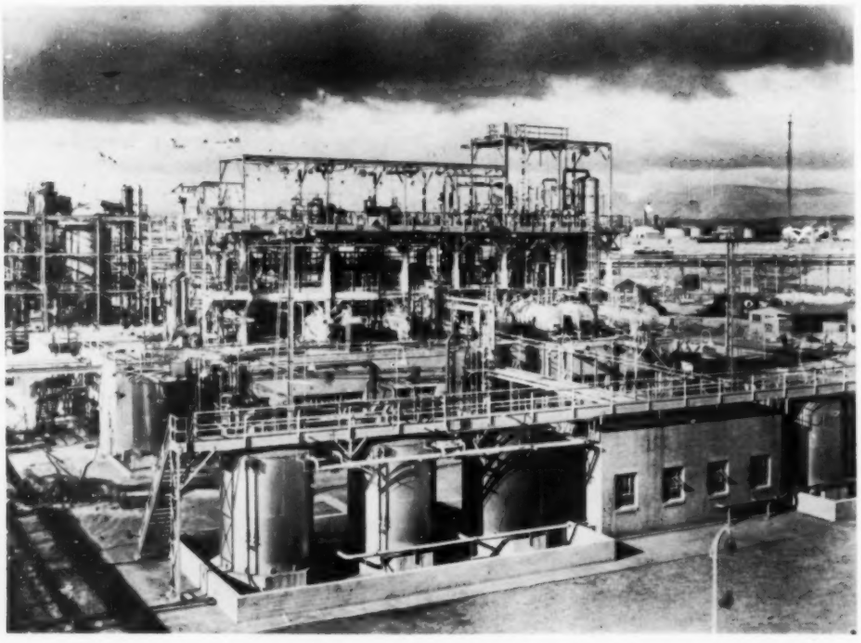
Among the many gases separated and products made are ethane, ethylene; propane, propylene, butane, butylene, isopropylalcohol, acetone, diacetone, ethyl alcohol, di-isobutylene, methyl-isobutyl-ketone, *sec*-butyl alcohol, methyl-ethyl-ketone, xylene, and epikote resins.

At the Shell Haven refinery, new plant which came onstream in July 1956, has been built for the manufacture of an alkyl benzene, which has a capacity of 30,000 tons per year of finished product. This plant was designed by BPM (Royal Dutch-Shell group) and constructed by Foster Wheeler Ltd., London. Solid detergents are produced from dodecyl benzene by sulfonation with oleum, followed by neutralization with caustic soda.

At Shell Haven, also, a plant is under construction for the production of anhydrous ammonia using refinery gas as a basic material. It is estimated that the plant will cost £6.5 million, and it is hoped to be brought into commission in the early part of 1958. Part of the anhydrous ammonia produced will be fed to a neighboring, independent chemical plant for the production of nitrogenous fertilizers.

Another part will be used in the production of Shell Chemical Co.'s new nitrogenous fertilizer, "Nitra-Shell," which was introduced to the market this spring; any surplus will be sold to industry generally. "Nitra-Shell" is sold with a guaranteed content of 20.5% nitrogen and 36% calcium carbonate.

Isopropyl alcohol plant of British Hydrocarbon Chemicals Ltd., at Grangemouth, Scotland (BP photo).



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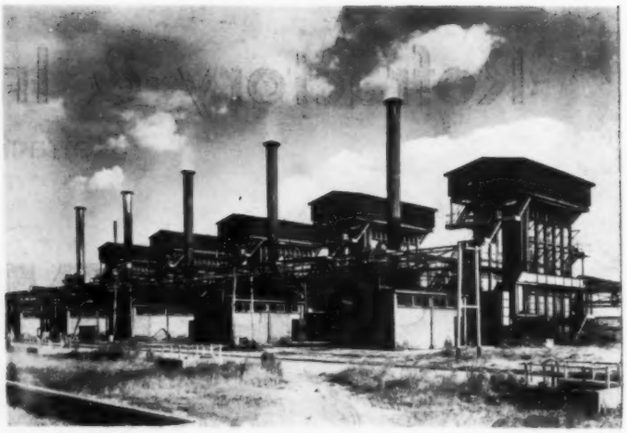
British Hydrocarbon Chemicals Ltd. No. 1 cracking unit, where incoming feed stock of BP's Grangemouth refinery is cracked to produce material for subsequent operations (BP photo).



Petrochemicals Ltd. "Catarole" cracking plant at Partington, near Manchester (Shell photo).

Esso Petroleum Co. Ltd. is the latest entrant among the petroleum companies into the petrochemical side, if the manufacture of elemental sulfur from refinery gases is excluded; for Esso was one of the earliest in that field. The company is entering the petrochemical field in a big way; the first plant now being constructed and scheduled to come into operation in 1958 is estimated to cost about £9 million. Foster Wheeler Ltd. is the contractor for the plant, and is undertaking mechanical design and construction.

The plant will crack some 250,000 tons per year of petroleum fractions into intermediates for use in the manufacture of various derivatives. It will produce ethylene, propylene, butylene, and butadiene—the latter serving as a base material for the preparation of synthetic rubber by the International Synthetic Rubber Co. Ltd., which is building a plant adjacent to Fawley for that purpose.

Other gaseous products will form the nucleus of a petrochemical industry, many details of which have not yet been made public. About 10,000 tons per year of ethylene will be taken by Monsanto for the manufacture of polyethylene. A further recovery unit is being erected which will raise the output of sulfur to 28,000 tons per year.

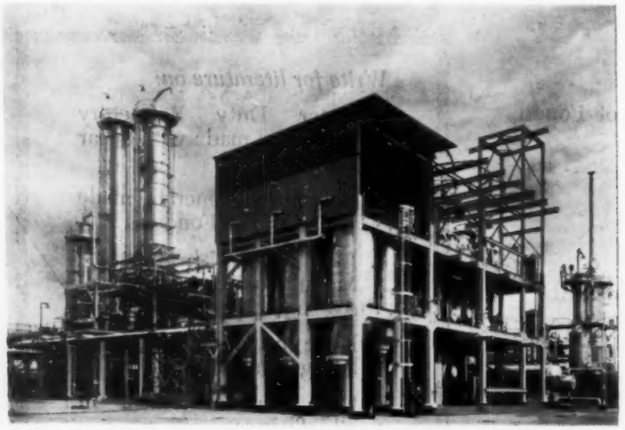
Imperial Chemical Industries Ltd., as mentioned previously, is in a different category from other manufacturers of petrochemicals. This company is primarily a chemical manufacturing company, and uses a purchased petroleum fraction definitely for the production of olefins; in fact, it definitely avoids the appellation "cracking" to these plants, although they are essentially similar in principle to other cracking plants used for the same purpose. The second of these two plants came into operation last year, and a third is now being erected and scheduled for operation in 1958. When these three plants are in operation, ICI will have an annual capacity of making 100,000 tons of ethylene, and 70,000 tons of propylene. Combined yield of these two gases is about 35% of the charging stock. Other hydrocarbons, C_4 and upwards, are also made in these plants, and are being increasingly used in the manufacture of chemicals.

A certain amount of motor gasoline is made and is blended with gasoline made by the hydrogenation of creosote oils. This gasoline is not sold as such; but, having a high octane blending value, it is sold for blending with gasolines produced by petroleum refining.

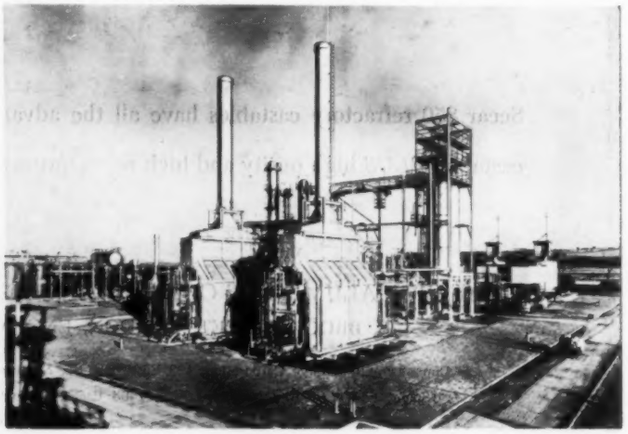
Hydrogen, methane, ethane, and other saturated hydrocarbon gases are at present mainly reacted with steam to produce hydrogen for various purposes.

Ethylene forms the base stock for the manufacture of polyethylene, ethylene oxide, and ethylene glycol.

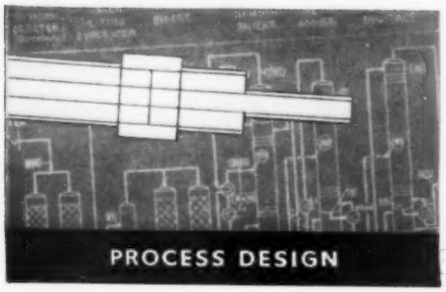
Propylene is used to give, by direct hydration under pressure in the presence of a catalyst, an isopropanol, from which acetone is produced for use as such, or in the manufacture of the plastic "Perspex." It is also used for the production of butyl alcohols by the carbonylation reaction. A new plant has been erected for the separation of butadiene which compound will be used



Hydrogen-fluoride unit (with driers and treaters in foreground) of the detergent alkylate plant at Shell Haven refinery (Shell photo).



No. 2 ethanol plant of British Hydrocarbon Chemicals Ltd.—one of two new plants at Grangemouth, Scotland, for manufacture of industrial alcohol for a variety of chemicals (BP photo).



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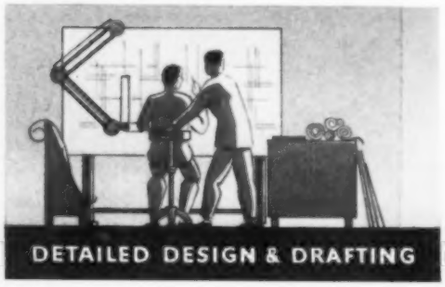

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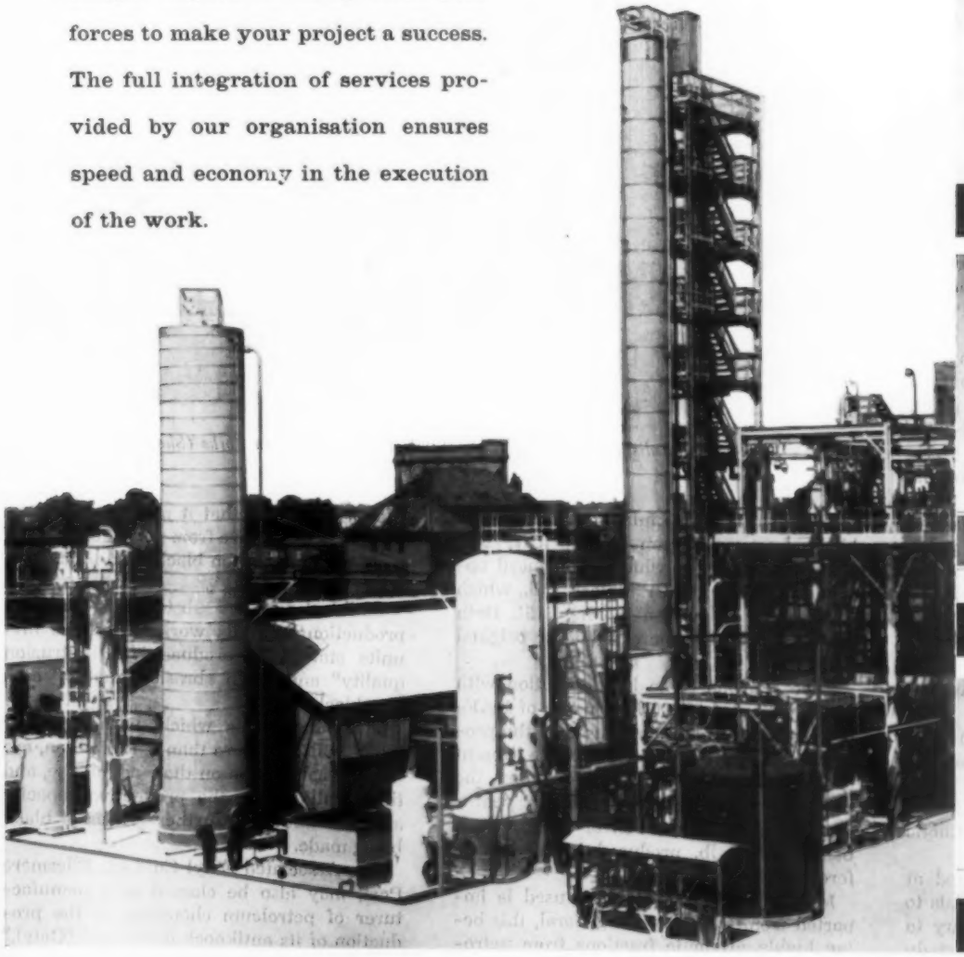

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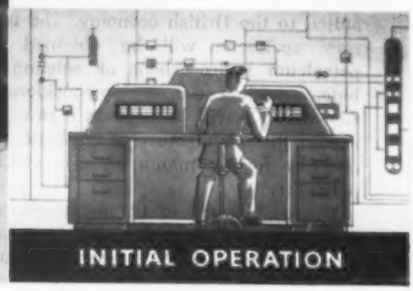

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for the production of "Butakone" products—copolymers of butadiene with acrylonitrile and other materials. The plant for the production of these bodies is nearing completion. One of the major recent developments of ICI has been the manufacture of "Terylene," which is a polyester fiber made by the reaction of ethylene glycol with paraxylene and terephthalic acid.

Other products are medium-chain alcohols made by the Oxo process.

In a lecture delivered by R. F. Goldstein before the Fawley branch of the Institute of Petroleum in the autumn of 1956, he gave the following estimate of the capacity for production of petrochemicals in the United Kingdom at the end of 1958.

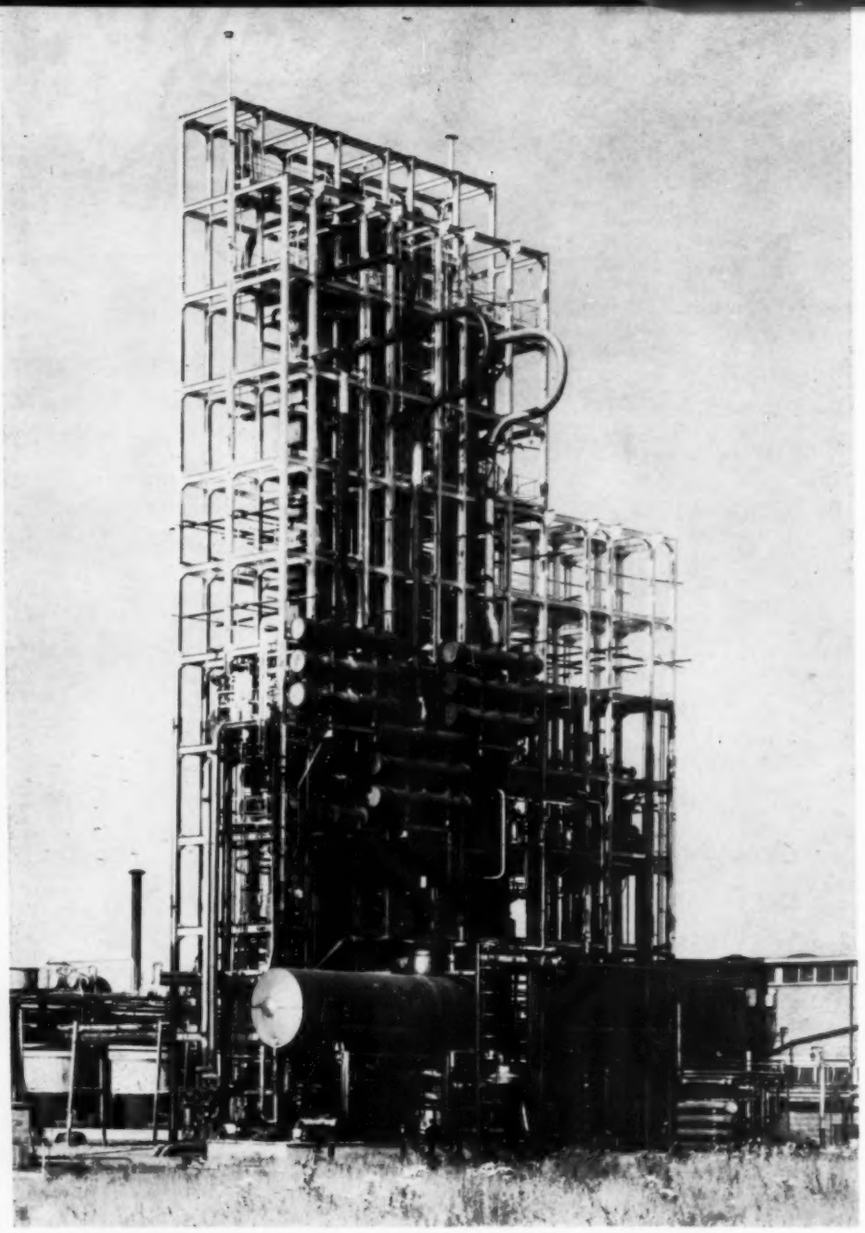
	Tons per Year
Ethylene	250,000
Ethanol	75,000
Ethylene oxide and derivatives	75,000
Ethyl chloride and ethylene dichloride	25,000
Polyethylene	125,000
Styrene	40,000
Isopropanol, acetone, etc.	75,000-100,000
C_4 solvents	20,000
Butadiene	50,000
GR-S and special synthetic rubbers	70,000
Dodecyl benzene	40,000
Higher oxo alcohols	30,000

Monsanto Chemicals Ltd. is also in a somewhat similar category to ICI—being in the main a chemical manufacturer using raw materials from other sources than petroleum. The company is, however, carrying out a program of about £8.5 million for the erection of a petrochemical plant at Fawley in conjunction with Esso Petroleum Co. Ltd. Three major plants are being erected, i.e., a high-pressure polyethylene plant due for completion in 1959; and an acrylonitrile plant and a copolymer plant, both due for completion before mid-1960. The full program envisages further polymer plants and plants for other chemicals, utilizing feed stocks from petroleum.

The high-pressure polyethylene plant is designed to produce a wide range of polyethenes, using ethylene produced by the Esso Petroleum Co. Ltd.

Acrylonitrile has not previously been produced in the UK, and the process chosen for its manufacture is considered the best suited to the British economy. The necessary acetylene will be obtained from petroleum hydrocarbons or calcium carbide, according to economic considerations. Acrylonitrile will be used as a raw product for the manufacture of synthetic fibers, and also for the manufacture of synthetic polymers.

The copolymers to be manufactured at Fawley vary from rubber-like materials to hard resins, and will be complementary to the styrene-butadiene polymers already made at Monsanto's Newport factory which are marketed under the name of "Tred"—which finds its major application in the manufacture of soles for shoes. The company also manufactures a wide range of oil additives for blending with lubes.



Light-aromatics distillation plant at Petrochemicals Ltd. Partington works (Shell photo).

There are two manufacturers of carbon black from petroleum in the UK, viz., Cabot Carbon Ltd., which commenced operations in 1950; and Philblack Ltd., which commenced production in May 1951. Both have considerably increased their original production.

Cabot Carbon came into operation with a production of 50,000 lb per day of HAF-type carbon black, mainly used in the production of tire tread stocks. At the present time, there are six units in production, the last one completed February this year—the total daily production of carbon black being 350,000 lb, produced in seven different grades.

Most of the basic material used is imported from the USA—in general, this being highly aromatic fractions from petroleum, which fractions, in this country, command a higher price as fuels than they do as carbon-black feed stock. More than 2 mmcf per day of refinery gas is also used in the plant.

Developments at present being made in the USA suggest that it may soon be possible to manufacture from petroleum a complete range of carbon blacks and thus avoid import from the USA.

Philblack Ltd. has substantially increased production from its works since the first units started to produce "fast extrusion quality" and "high abrasion quality" carbon blacks.

Two new plants which, with auxiliary plant, will cost more than £1.5 million, are nearing completion on the existing site, and these will double the productive capacity and also allow for further grades of black being made.

The Associated Ethyl Co. Ltd., Ellesmere Port, may also be classed as a manufacturer of petroleum chemicals in the production of its antiknock compound "Octyl," i.e., tetraethyl lead, formerly known as "Ethyl."

The ethyl and ethylene chloride used in this manufacture are made from ethane and ethylene separated from petroleum gases END

C. D. Adams is a graduate of Queens University, Kingston. He joined Imperial Oil in 1946 at Montreal refinery and was transferred to the engineering division in Sarnia in 1950, into the General Inspection Department. For the past three years he has been following field construction of new processing facilities.

HOSE-HANDLING FACILITIES ON A MODERN REFINERY DOCK

IN keeping with the latest trend in industry towards speed of operation and increased production, oil companies are continually developing more effective means of handling cargo hoses at their marine terminals and thereby reducing port time, hose replacement costs and subsequent shipping economics.

Imperial Oil Ltd. recently spent 1½ million to modernize and enlarge the docking facilities at their Halifax refinery on Canada's east coast. Two new docks have been built and one existing dock enlarged. Each dock is suitable as a loading or unloading berth for a modern tanker and the terminal can berth three super tankers simultaneously. To speed loading and unloading of petroleum products and crude oils, each dock is equipped with new improved hose handling facilities. The hose handling towers complete with derricks, walkways, and stairs are of structural steel. Walkway grating is of aluminum to reduce sparking hazard. Provision is made on each tower for the accomodation of a derrick from which is suspended three two ton electric trolley hoists for lifting the outboard end of the cargo hose, motor and hoist drum for operation of the derrick boom and eight two-ton fixed electric hoists for handling of eight hoses. Controls for all motors are mounted at one location on the first platform.

The derrick which is supplied for each

View of hose winches

View of boom winch

Hose in loading position

tower consists of a double boom which pivots on pins fixed to the tower legs and a frame which is bolted to the top of the tower. The derrick boom consists of two structural steel side struts placed 18 ft apart and connected at the outer end by a rigged structural steel member. The side struts have a hub welded onto them at the lower end which is bored and bronze bushed to fit the pivot pin on the tower structure. The top end of the side struts are equipped with gusset plates which are bored to suit the boom line link pins and hoist girder pivot pins.

The hoist girder, suspended from the upper end of the boom, is a structural steel beam with top flange reinforced by a steel channel. This girder is pivoted at each end to the derrick booms and hangs vertically at all times, but pivots sufficiently to allow side pull from the hoists which are mounted on it.

Each boom is operated by two sets of boom lines which lead over suitable guide sheaves to the boom hoist drum.

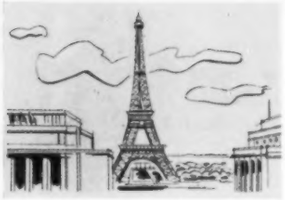
The cargo hoses are stored in the vertical position at all times being held in this position by the electric hoists. The inboard end of the hose is connected to the piping manifold and the outboard end rests on the dock against the bottom of the hose handling tower. In operation the derrick boom is raised to its vertical position, the cable of the electric trolley hoist is lowered to pick up the outboard end of the cargo hose raising it to clear the ships deck. By combined operation of the boom hoist, electric trolley hoist and fixed electrical hoists used in storing the hose, the outboard end of the hose is brought into position with the manifold on the ships deck. Following coupling of the hose to the ship manifold, the outboard end of the cargo hose is unhooked from the dock handling facilities, and the weight of the hoses is taken by the ships jib crane.

This allows for rise and fall of the ship in the water and permits drifting of the ship during loading and unloading without damage to the hose.

On completion of loading, the product left in the hose is drained to the ship on the outboard side and to an oil sump located below the dock on the inboard side from where it is pumped to the refinery slop system. The outboard end is again hooked to the tower boom and returned to its stored position in the hose handling tower.

Benefits derived from the new hose handlng facilities have been reduction of manpower for coupling hoses, reduction in hook-up time by one-third the manhours and considerable reduction in manhandling and subsequent damage to the hoses. END

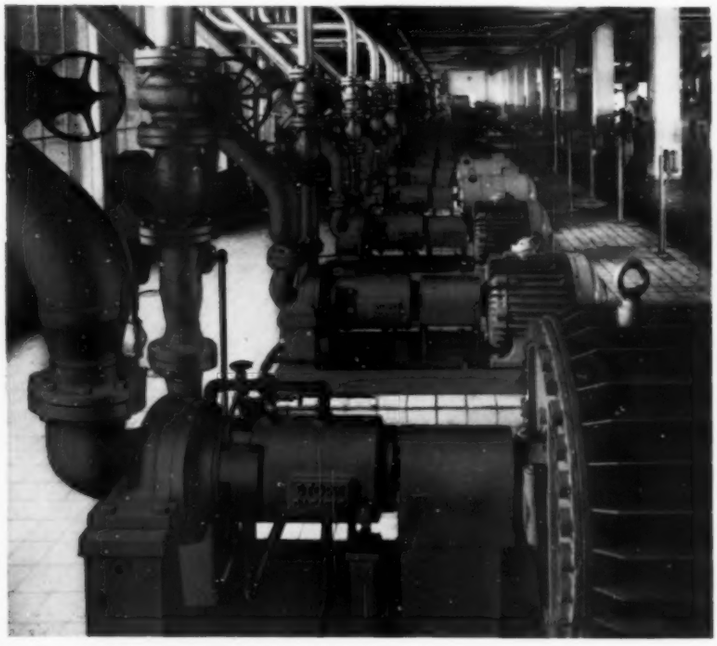
General view of hose-handling structure



BATIGNOLLES-PACIFIC centrifugal pumps in propane service at the BERRE refinery, belonging to Compagnie de Raffinage Shell-Berre.

Manufactured and serviced by:

BATIGNOLLES-CHATILLON
5, Rue de Monttessuy, Paris (7e), France



STORK-PACIFIC centrifugal pumps at the Pernis refinery of N. V. de Bataafsche Petroleum Mij.

Manufactured and serviced by:

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N. V. (V.M.F.) Hengelo (o), The Netherlands

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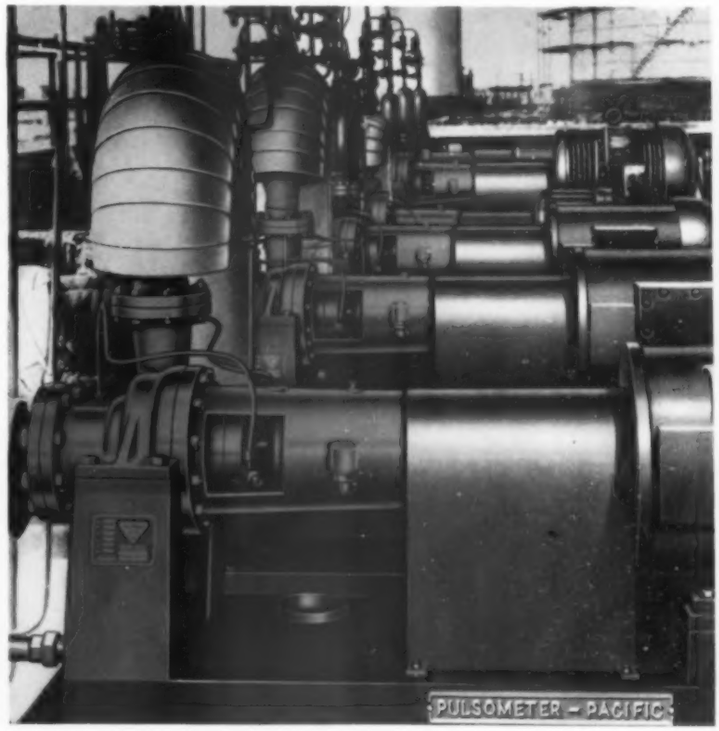

PULSOMETER-PACIFIC centrifugal pumps at the Coryton refinery of The Mobil Co. Ltd.

Manufactured and serviced by:

THE PULSOMETER ENGINEERING COMPANY LTD.
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annual review of

UNITED STATES PATENTS ON PETROLEUM REFINING

by Heinz Heinemann and Harold Shalit

During the past year two patent reviews covering subjects related to petroleum refining have been published in World Petroleum. ("Reforming", February 1957 and "Desulfurization", June 1957.) The number of patents which have been issued during the year has been so large, however, that close to 400 patents not previously reviewed had to be considered for this article and that 135 patents will actually be discussed. In order to stay within the available space, it has been necessary to limit abstracting of individual patents to the shortest possible digest. We confidently hope that this review, in spite of its limitations and shortcomings, will once again give a survey of the degree of activity as well as the directions and trends of petroleum refining research.

Isomerization and Alkylation. Relatively few patents covering the isomerization of hydrocarbons have appeared this year, other than patents treating isomerization as a part of catalytic reforming.

In Sinclair Refining Company's 2,766,302 R. H. Elkins isomerizes alkanes and cycloalkanes over a platinum-acidic base catalyst at 650-1000°F, 200-1000 psi and a hydrogen to oil ratio of between 1 to 1 and 20 to 1 in the presence of 0.7-1% chemically combined sulfur. Aromatics formation and hydrocracking are suppressed. R. E. Dixon and C. S. Kelley (2,764,624 to Phillips Petroleum Co.) describe an aluminum chloride isomerization of butanes in which the hydrocarbon effluent is treated with caustic, then water is removed from the treated effluent and returned to the caustic solution. M. M. Holm in California Research Corporation's 2,748,241 claims a xylene isomerization process with removal of the desired isomer, in which the hydrocarbon mixture is contacted with hydrogen and a hydrogenation-dehydrogenation catalyst under conditions permitting existence of a minor amount of naphthene, in equilibrium with xylenes.

The number of new alkylation patents has increased over previous years. H. J. Hepp and F. E. Frey (2,781,409 to Phillips Petroleum Co.) prepare diisopropyl from isobutane and ethylene by algylation of isobutane with cracked gases over an aluminum halide catalyst. Means of operating an HF alkylation process are disclosed in Phillips Petroleum Company's 2,764,623 (A. B. Leonard and G. R. Hettick), while a sulfuric acid process is the subject of Esso Research and Engineering Company's 2,775,636 (W. H. Rupp). H. M. Hart in 2,768,987 (to Standard Oil Co. of Indiana) describes an apparatus for hydroalkylation. In two Universal Oil Products Co. patents (2,754,338 and 2,754,339) H. Pines discusses the dehydroalkylation of a bicyclic terpene by reaction with an olefinic hydrocarbon at 150-400°C in the presence of alkali metals or their hybrides.

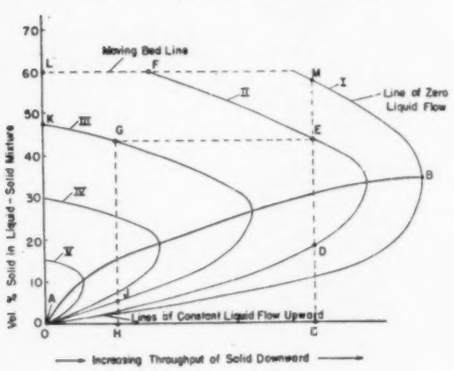
J. T. Kelly and R. J. Lee in American Oil Co.'s 2,758,960 claim a motor gasoline containing 10-25% of an alkylate produced by cold acid alkylation of isobutane and a thermally cracked naphtha boiling between 120-185°F.

The preparation of alkyl substituted naphthenes, according to Sun Oil Co.'s 2,767,228 (R. M. Kennedy and A. Schneider) consists of introducing cyclohexylflouride into an admixture of BF_3 and an isoparaffin in liquid homogeneous phase. In another Sun Oil Co. patent (2,776,326) Schneider demethylates substituted aromatics by non-catalytic heating to 500-800°C at 75-700 psig in the presence of certain acyclic hydrocarbons.

Several patents deal with the alkylation of aromatics. According to W. F. Gorham and J. A. Stenstrom (2,778,862 to Union Carbide and Carbon Corp.) monoethyl toluene is produced from ethylene

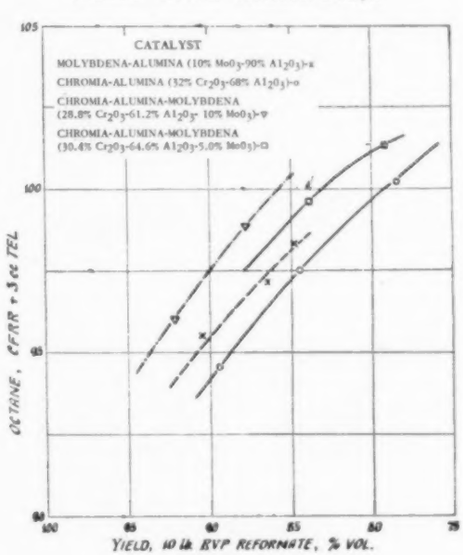
T. S. Mertes Et Al

Treating of Liquids with Granular Solids


Moving Bed Line
Line of Zero Liquid Flow
Lines of Constant Liquid Flow Upward
Vol % Solid in Liquid - Solid Mixture
Increasing Throughput of Solid Downward

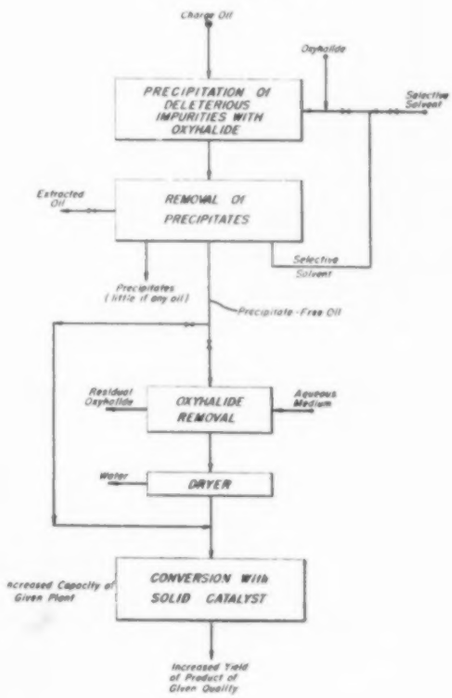
W. A. Stover

Alumina—Chromia—Molbdena Catalyst



W. A. Junk, Jr., Et Al

Chemical Refining and Catalytic Conversion of Hydrocarbon Oils



and toluene at 60-90°C over $AlCl_3$. Polyethyltoluenes are disproportionated at the same conditions. The mono-propylation of toluene is disclosed in Union Oil Co.'s 2,777,007 by D. A. Skinner and W. L. Wasley. Phosphorous pentoxide is used as the catalyst at 75-100°C. E. V. Kirkland (2,754,341 to the American Oil Co.) propylates aromatics over a solid phosphoric acid catalyst, saturated with boron trifluoride. G. L. Hervert and H. J. Bloch (2,761,000 to Universal Oil Products Co.) extract olefin isomers with 80-95% H_2SO_4 and contact the acid containing extract with aromatics at alkylation conditions. The nuclear alkylation of an aromatic with ethylene over an hydride of an alkali metal is proposed by E. Field and M. Teller in Standard Oil Co. of Indiana's 2,780,660. The catalyst may be supported on charcoal or alumina.

Three Standard of Indiana patents deal with disproportionations. In 2,780,659 D. A. McCaulay and A. P. Lien form diethylbenzenes and xylenes from ethylbenzene with a BF_3-HF catalyst at 0-125°F. According to 2,753,383 and 2,753,384 Lien and McCaulay convert poly-n-propyl benzenes and benzene to n-propylbenzene at 0-120°F with a BF_3-HF catalyst.

Reforming-Hydrogenation-Dehydrogenation Catalytic reforming continues to be the most active field in petroleum refining technology. This is evident from the number of patents issued even since the last review of this subject appeared a few months ago.

A number of Esso Res. & Eng. Co. patents covers phases of fluid hydroforming. C. N. Kimberlin and E. M. Gladrow in 2,773,810 describe preparation of a hydroforming catalyst. Aluminum is reacted with an anhydrous alcohol, diluted with a hydrocarbon. The alcoholate is admixed with acetic acid and a zinc acetate solution, and a hydroforming component is incorporated into the slurry. According to R. W. Tate and C. E. Heminger's 2,773,804 naphthas are simultaneously hydroformed and desulfurized in a fluidized bed reactor over a molybdena-alumina catalyst. R. J. Joder (2,773,015) proposes means of operating a fluidized hydroformer and to strip, reduce and remove water from regenerated catalyst. R. J. Fritz, A. Nicolai and E. W. S. Nicholson (2,777,803) claim that freshly regenerated hydroforming catalyst should be contracted with hydrogen containing gas at temperatures well below regenerator temperature. In 2,772,217 Nicholson controls the water content of regenerated catalyst to avoid a deleterious effect on the reforming operation. Patent 2,780,661 (C. E. Hemminger and C. W. Tyson) discloses a method of subjecting naphtha first to fluid bed hydroforming and then to fluid bed hydrodealkylation. Reforming with a platinum or molybdena catalyst in the presence of 0.1-10% boron oxide is described in C. W. Tyson's 2,769,769. Boron oxide is continuously fed to the hydroforming stage to replace that lost by volatilization.

A combination of reforming and hydrogen donor diluent cracking (see section on "Cracking") is the subject of Esso's 2,772,215 (C. E. Hemminger). J. D. Bushnell and R. L. Berg in 2,772,220 increase the useful on-stream time of a heat exchange unit for preheating reformer feeds by adding an oxidation inhibitor to the feed stock.

Four Houdry Process Corp. patents deal with platinum reforming and platinum catalysts. T. H. Milliken, Jr. (2,785,138) stabilizes a platinum catalyst against rapid deactivation by pretreatment with hydrogen containing up to 1 vol. % hydrogen chloride. H. Heinemann (2,785,139) prevents migration of ferric chloride on the catalyst by treating it with a gas consisting of hydrogen and HCl in an amount not greater than 15% of the HCl partial pressure, based on the Kp value for the formation of iron chloride at treating conditions. J. Newman in 2,779,716 discloses a single reactor vessel, which provides a plurality of reactor chambers, which may have a common, uninsulated wall of nominal thickness. According to S. W. Weller's 2,776,934 sulfur containing olefins can be hydrogenated at 100 psig and 750-1000°F over a platinum-alumina catalyst, which has been impregnated with magnesia.

A group of Standard of Indiana patents describes features of the Ultraforming process. An Ultraforming reactor system with a swing case for catalyst regeneration is disclosed in 2,773,014 (J. F. Snuggs, J. A. Bock and J. E. Wolf). Wolf, D. H. Wagner and J. A. Bock (2,773,013) use part of the hydrogen produced in the system to desulfurize the feed naphtha. Similarly in 2,773,008 R. J. Hengstebeck employs hydrogen produced by hydroforming for hydroforming a plurality of stocks. R. J. Hengstebeck and M. F. Oxenweiter (2,776,248) claim an improved method for supplying heat to a hydrocarbon reforming process using a fluidized platinum catalyst.

Universal Oil Products Co.'s 2,774,743 (J. Hockstra) discusses preparation of a platinum-alumina catalyst having an apparent bulk density of below 0.5 g/cc. Other UOP patents deal with various phases of Platforming. V. Haensel in 2,781,324 prepares a catalyst by commingling alumina with a platinum compound-ammonium hydroxide solution and an oxidizing agent to form a final catalyst containing 0.01-1% Pt. H. R. Appell (2,786,752) describes a method of recovering platinum from a reforming catalyst. V. Haensel and C. G. Gerhold (2,781,298) operate a two-stage reforming process, in which C_9 and C_{10} hydrocarbons are first dehydrogenated and dehydrocyclized with a minimum of hydrocracking. The product is mixed with C_8 and lower hydrocarbons and isomerized. The same authors in 2,773,809 split a naphtha into two fractions. The lower boiling fraction is reformed at much greater intensity than the higher boiling fraction. Higher hydrogen partial pressure is used for the high boiling fraction.

A reforming catalyst consisting of platinum or palladium on silica and an auxiliary carrier material is disclosed by P. A. Lefrancois, E. W. Riblett and W. P. Burton (2,777,805 to the M. W. Kellogg Co.). A water soluble promoting agent, such as an alcohol or ketone is employed in the preparation. J. E. Connor, Jr. (2,773,742 to The Atlantic Refining Co.) prepares complex platinum and palladium hydroxides, in which the metal is in the cation in aqueous solution. Aqueous solutions of the correspondingly metal complex salt are passed over an anion exchange resin. P. C. Keith (2,779,714 to Hydrocarbon Research Inc.) describes a naphtha reforming process in which heat is supplied to the reactants from a substantially isothermal source.

Another group of patents refers to non-platinum reforming catalysts. W. P. Burton and E. W. Riblett (2,768,933 to The M. W. Kellogg Co.) increase the efficiency of a molybdena reforming catalyst by calcining it at 1250°F and then treating it at 930-975° with hydrogen and 0.1-10 mol.% water. Phillips Pet. Co.'s 2,784,162 (J. W. Myers and L. C. Mabry, Jr.) describes a catalyst comprising alumina, activated with 0.05-1% fluorine and admixed with 0.1-10% titania or iron oxide, which is then impregnated with 2-25% molybdena. A fluid bed reforming catalyst may, according to 2,776,247 (V. J. Anhorn, M. M. Stewart and W. E. Morrow to Gulf Research & Dev. Co.) consist of molybdena-alumina, containing 10-25% of carbon. T. F. Doumani (2,780,584 tot Union Oil Co. of Cal.) prepares a nickel reforming catalyst on alumina, which has been sulfided to not more than 0.2 moles sulfur per mole nickel to result in minimized cracking activity.

Three Socony-Mobil Oil patents disclose reforming and dehydrogenation catalysts and processes. W. A. Stover in 2,773,846 (see accompanying graph) impregnates molybdena on a chromia-alumina cogel to result in a catalyst containing 10-30% Cr_2O_3, 50-98% Al_2O_3 and 1-20% MoO_3. C. L. Gutzeit and W. H. Lang (2,773,837) impregnate chromia-alumina cogel with phosphorus pentoxide. S. T. Hadden (2,772,315) continuously produces ethylene from propane in the presence of sulfur dioxide.

Reformer feed stock preparation is another active subject. W. A. Junk, Jr., W. D. Schmidt, H. S. Seelig and W. L. Flemming (2,780,582 to Standard of Indiana; see illustration) remove nitrogen compounds from naphthas by treatment at below 300°C with an oxyhalide of sulfur or phosphorous and removal of precipitates formed. C. G. Gerhold (2,773,007 to Universal Oil Products Co.) hydrogenates nitrogen compounds over a hydrogenation catalyst and strips ammonia from the reactor effluent. Three other UOP patents deal with arsenic removal. E. J. Bicek in 2,769,770 reduces the arsenic content of reformer feeds by irradiation with ultraviolet light. In 2,782,143 Bicek removes arsenic by treatment of naphtha with cumene hydroperoxide and acetic acid, followed by water washing. G. R. Donaldson (2,778,779) treats the arsenic containing feed with ferric oxide and washes the product with water, to remove the water soluble oxidized arsenic compounds.

Refining

A. *Removal of heavy metals.* Cracking of increasingly heavy crude oil fractions has focussed attention on the removal of metals. This is expressed in a larger number of patents on the subject. F. W. B. Porter and J. W. Hyde (2,758,060 to British Pet. Co.) remove sodium and vanadium from hydrocarbons by treatment with bauxite in the presence of hydrogen at 700-800°F and 800-1000 psig. The same company's 2,764,525 (Porter and R. P. Northcutt) uses alumina, containing 5-15% ferric oxide instead of bauxite. Fuller's earth may be substituted according to 2,766,183 (Porter and Northcutt).

N. P. Peet (2,777,802 to Esso Res. & Eng. Co.) employs high molecular weight condensed ring aromatics as solvents for metal complexes in crude oil. K. E. Kavanaght and R. P. Chesluck in 2,744,-853 (to The Texas Co.) treat vanadium, nickel and iron containing stocks with elemental iodine in non-aqueous form, to convert oil soluble metal compounds to non-soluble, solid metal and iodine containing compounds, which are separated. According to another Texas Co. patent (2,778,777 R. Powell) metal compounds are removed from crude by contact with dilute sulfuric acid in excess of the stoichiometric amount required for conversion to water-soluble metal salts. The salts formed are removed by water washing.

B. *Treatment of Gasolines.* V. E. Yust and J. L. Bame (2,750,267 to Shell Dev. Co.) claim the use as a lead scavenger of a mixture of halohydrocarbon scavengers and of a smaller amount of a hydrocarbyl substituted phenyl derivative of an oxide or hydride of arsenic, antimony or bismuth. J. L. Jezl and I. W. Mills (2,745,793 to Sun Oil Co.) delead gasoline by treatment with 0.5-5% silica gel at 250-400°F.

Stabilization of cat. cracked gasoline is the subject of two Gulf Research & Dev. Co. patents. E. M. Sutphin in 2,786,016 treats with boron trifluoride, promoted with about 0.05% of sulfuric acid or sulfur trioxide. H. Beuther and W. C. Offutt in 2,786,-018 promote the boron trifluoride used with 0.05% fluosulfuric acid.

The engine cleanliness of cat. cracked naphthas can be improved, according to G. P. Hammer (2,-756,181 to Esso Res. & Eng. Co.) by separately treating a lower and a higher boiling fraction of the naphtha with phosphorus pentoxide and combining the fraction after separating high boiling fractions formed. Another Esso patent describes an antistalling gasoline, containing 0.2-0.5% morpholine (2,784,-067 G. W. Duncan, W. E. Lifson and J. P. Haworth).

W. I. Denton, W. E. Garwood and J. N. Miale (2,768,121 to Socony Mobil) upgrade hydrocarbons containing sulfur, nitrogen and heavy metals by treatment with iodine, hydrogen iodine or mixtures thereof. According to 2,769,766 (H. O. Folkins and A. Kempf to The Pure Oil Co.) the detonation characteristics of cat. cracked gasoline are improved by contacting the 100-300°F fraction with 0.1-10% maleic anhydride, followed by caustic and water washing. L. P. Evans in Socony-Mobil Oil Co.'s 2,769,752 prepares aviation blending stocks by extracting aromatics from a naphtha and contacting the extract with a non-aromatic fraction, which extracts the aromatics from solution. The gum content and storage stability of olefinic gasolines is improved, according to P. W. Garbo's 2,774,720 (to Hydrocarbon Research, Inc.) by hydrogenation over a siliceous material, containing a minor amount of a difficulty reducible metal oxide. Olefins are not saturated.

C. *Purification.* The removal of nitrogen compounds from gas oils is proposed by N. L. Kay, G. W. Hendricks and R. A. Hanson (2,744,053 to Union Oil Co. of Cal.). The oils are contacted with a moving bed of clay, alumina or silica at specific conditions. Chyn Duag Shiah in 2,745,792 removes asphalts and colloidal carbon from hydrocarbons by

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treatment with a coordination compound of boron trifluoride at 15-60°C and atmospheric pressure. J. McAffee and A. G. Smith (2,753,293 to Gulf Oil Corp.) claim an improved process for the sulfuric acid treatment of relatively heavy petroleum stocks. S. B. Becker (2,754,252 to Standard of Ind.) refines sulfur containing hydrocarbon oils by contact with 10-300 vol.% of a perfluoro alkanoic acid, having 2-5 C atoms/mole. Sun Oil Co.'s 2,771,404 (J. L. Jezl and A. Schneider) deals with the regeneration of an alkaline treating agent, which has been used in the removal of sulfur compounds from mineral oil. This is accomplished by reaction with ethylene oxide or propylene oxide.

Stabilization of heating oil with respect to at least one of color or sediment is accomplished, according to Socony-Mobil's 2,754,253 (C. A. Duval, and W. F. Rosen) by first dyring the oil and then treating it with an aqueous alkaline treating solution containing at least 29% alkali metal hydroxide A. E. Brehm and T. B. Tom (2,756,185 to Standard of Indiana) produce an odorless naphtha by a series of steps, involving treatment with sulfuric acid. A. L. Forchiello (2,767,119 to General Aniline and Firm Corp.) decolorizes petroleum hydrocarbons by contact with a pyrrolidone.

A defluorination process for the removal of combined fluorides and of HF is described in Phillips Pet. Co.'s 2,769,853 (G. R. Hettick). Disproportionation of ethylbenzene to benzene, 1,3-diethylbenzene and 1,3,5-triethylbenzene by treatment with HF and borontrifluoride is claimed by A. P. Lieu and D. A. McCaulay in Standard of Indiana's 2,773,109.

D. *Separation.* Separation of 1,3,5-ethylxylene from meta diethylbenzene by treatment with BF_3 and HF at below 50°C is described by D. A. McCaulay and A. P. Lien in 2,753,386 (to Standard of Indiana). M. R. Fenske separates p-xylene from a C_8 aromatic hydrocarbon fraction (2,778,864 to Esso Res. & Eng. Co.) by mixing with antimonytrichloride and fractional crystallization of the complexes formed. A. C. Nixon and C. M. Deal, Jr. (2,768,220 and 2,768,222 to Shell Dev. Co.) similarly separate isomeric C_8 aromatics by complex formation and fractional crystallization with antimony bromide.

Urea extraction is used by E. Gorin (2,759,915 to Socony-Mobil) to separate a straight chain α-olefin of more than 8 C atoms from an isomer of the same skeleton, but different double bond position. In 2,759,818 and 2,759,919 Gorin (to Socony-Mobil) proposes separation of straight chain aliphatic compounds of at least 6 C atoms from similar compounds of lesser saturation by complex formation of the more saturated compounds with urea.

Separation of benzene from close boiling paraffins by extraction with sulfur dioxide and recovery from the extract in a crystallization process is claimed by R. A. Findlay (2,758,141 to Phillips Pet. Co.). E. H. Lebeis and F. S. Bondor (2,768,131 to Houdry Process Corp.) extract aromatics from naphthas with pentadione-2,4 as solvent. In another Houdry Process Corp. patent (2,758,956) H. Shalit and S. W. Weller selectively extract more polar from less polar substances with a liquid, characterized by a phosphoric acid amide. N-acyl derivatives of pyrrolidine are proposed by W. T. Nelson (2,753,381 to Phillips Pet. Co.) as solvents for the extraction of unsaturated hydrocarbons from less unsaturated hydrocarbons of similar boiling point.

R. A. Van Nordstrand, H. L. Pelzer and J. W. Teter (2,759,917 to Sinclair Refining Co.) remove cyclohexane and methylcyclopentane from a petroleum fraction, boiling between 130 and 230°F by forming an adduct with thiourea in the presence of a small amount of water. Treatment of an olefin-free naphtha for the separation of aromatics is disclosed in Standard of Indiana's 2,768,986 (C. E. Johnson, A. P. Lien and D. A. McCaulay). Anhydrous alkane-sulfonic acid and a silver salt, that is highly soluble in this acid are the agents.

A solid cuprous halide reagent for separating diolefins from hydrocarbon mixtures is prepared, according to J. C. Hillyer and A. J. Dees (2,756,267 to Phillips Pet. Co.), by precipitating solid cuprous halide-diolefin complex from solution, drying the precipitate, mixing with a cellulosic fibric carrier material and heating to decompose the complex.

Separation by adsorption is the subject of two Sun Oil Co. patents. E. R. Weatherly in 2,754,344 regenerates silica gel, which has become deactivated by accumulation of polar compounds, by treatment with an aromatic liquid at a higher temperature than that used during adsorption. T. S. Mertes and H. B. Rhodes (2,745,888 see illustration) describe a method and apparatus for countercurrently treating a liquid with a granular solid. D. S. Maisel (2,754,343 to Esso Research & Eng. Co.) discloses an improved fixed bed adsorption process, employing a non-uniform particle size adsorbent.

Cracking

1. *Thermal Cracking.* Thermal vapor phase cracking of crude residua in a fluidized bed of coarse particles of a dense, non-porous and abrasion resistant contact material is described in Esso Res. & Eng. Co.'s 2,756,195 (C. E. Adams). H. J. Hepp (2,750,420 to Phillips Pet. Co.) discloses a process for the pyrolysis of hydrocarbons at 1200-3000°F, wherein over-reacting and carbon formation are minimized. Another Phillips patent (2,752,231, L. C. Bearer) provides means and methods for distributing reactant material throughout a pebble conversion chamber in response to at least one gas variable.

2. *Moving Bead Catalytic Cracking.* Moving bed techniques are described in four Socony-Mobil patents. E. V. Bergstrom in 2,756,193 continuously measures the flow rate of a gravitating stream of particulate solid material. The flow of lift gas for the catalyst lift is determined on the basis of the solids flow. V. O. Bowles (2,758,067) provides means of introducing contact material and liquid hydrocarbon charge into the reaction zone of a moving bed unit. R. H. Halik (2,773,016) operates a moving bed process, in which the bed and the gaseous reactants have different temperatures. S. D. Dalton (2,779,717) discloses a combination process, involving moving bed cat. cracking, fractionation and vacuum fractionation.

Two Houdry Process Corp. patents deal with moving bed catalytic cracking. T. A. Burtis (2,767,-128) describes a recycling apparatus, in which a downwardly moving bed of solids is contacted with a fluid and subsequently elevated to a position from whence the cycling operation commences anew. G. D. Myers in 2,786,800 discusses a method of withdrawing a side stream of catalyst from a moving bed unit, ellutriating it and making up fines losses with fresh catalyst.

3. *Coking and Cracking of Residua.* P. H. Emmett in Gulf Research & Dev. Co.'s 2,744,057 cracks high boiling hydrocarbons over silica-alumina or clay catalysts, which have been prepared by base exchanging barium, magnesium, calcium or strontium on the support.

A fluidized coking technique is described in Pan-American Southern Corp.'s 2,739,104 (R. B. Galbreath and R. H. Stewart, Jr.). A number of Esso Res. & Eng. Co. patents covers aspects of the same subject. In 2,763,601 H. Z. Martin, H. E. W. Burnside, F. T. Barr and R. W. Krebs suggest a method of coking residua in a fluidized bed of coke particles. According to 2,742,403 (E. W. S. Nicholson and S. B. Sweetser) heavy residues are coked by first contacting the feed with hot, inert solids and then passing the pre-coked feed thru a fluidized mass of coarse inert solids, containing small amounts of relatively fine cracking catalyst. C. E. Adams and C. N. Kimberlin (2,763,600) combine the coking of heavy residua in contact with fluidized inert solids with the cracking of the total volatile coking product on a subdivided suspended catalyst. A. H. Schutte in Lummus Co. patent 2,742,410 states, that the operation of a continuous coking process is more effective, if the contact coke particles are dried carefully. A moving bed coking process, operating at 750-950°F and 100 to 3000 psi is disclosed in Esso Res. & Eng. Co.'s 2,775,546 (C. N. Kimberlin and R. W. Krebs).

J. H. Watkins in two Universal Oil Products Co. patents describes the conversion of hydrocarbons by contact with a molten material. In 2,749,288 polynuclear aromatics are introduced into the reaction zone in sufficient amounts to dissolve asphaltic materials, formed during the reaction. According to 2,768,935 hydrocarbonaceous material is introduced into the lower portion of a vertically elongated body of molten catalyst. A suspension is formed and passed upwardly thru the reaction to a separating zone, where hydrocarbons are separated from molten catalyst, which is recycled.

Hydrocracking of a residuum can be practiced in accordance with 2,752,287 (F. W. B. Porter and R. P. Northcutt to British Pet. Co.) by contact at devated pressure and temperature with a cobalt-molybdena-alumina catalyst in the presence of hydrogen. The treated residue, after removal of H_2S is fractionated for recovery of a gas oil fraction.

4. *Cracking Catalyst Preparation and Regeneration.* A porous, adsorptive catalyst is prepared, according to C. J. Plank and P. D. Branton (2,763,622 to Socony-Mobil) by mixing less than 50% raw kaolin with silica hydrogel, prepared at a gelation pH range of 2-4, and drying the composite. C. P. Wilson, Jr. (2,777,822 to W. R. Grace & Co.) prepares a silica-alumina catalyst by commingling sulfuric acid and sodium silicate solution to form a silica hydrogel in an aqueous slurry at pH 9.5-10.5, aging the hydrogel in the slurry, adding sulfuric acid to bring the pH to 7 and commingling with aluminum sulfate solution. An improved cracking catalyst consisting of silica-magnesia, containing 0.1-2% of strontium is claimed in Sinclair Refining Co.'s 2,731,397 (H. Erickson). W. C. Offutt and A. C. Whitacker (2,744,056 to Gulf Research & Dev. Corp.) propose to reduce carbon deposition, during the catalytic cracking of high boiling hydrocarbons, by employing a halloysite catalyst, containing about 2-10% magnesia.

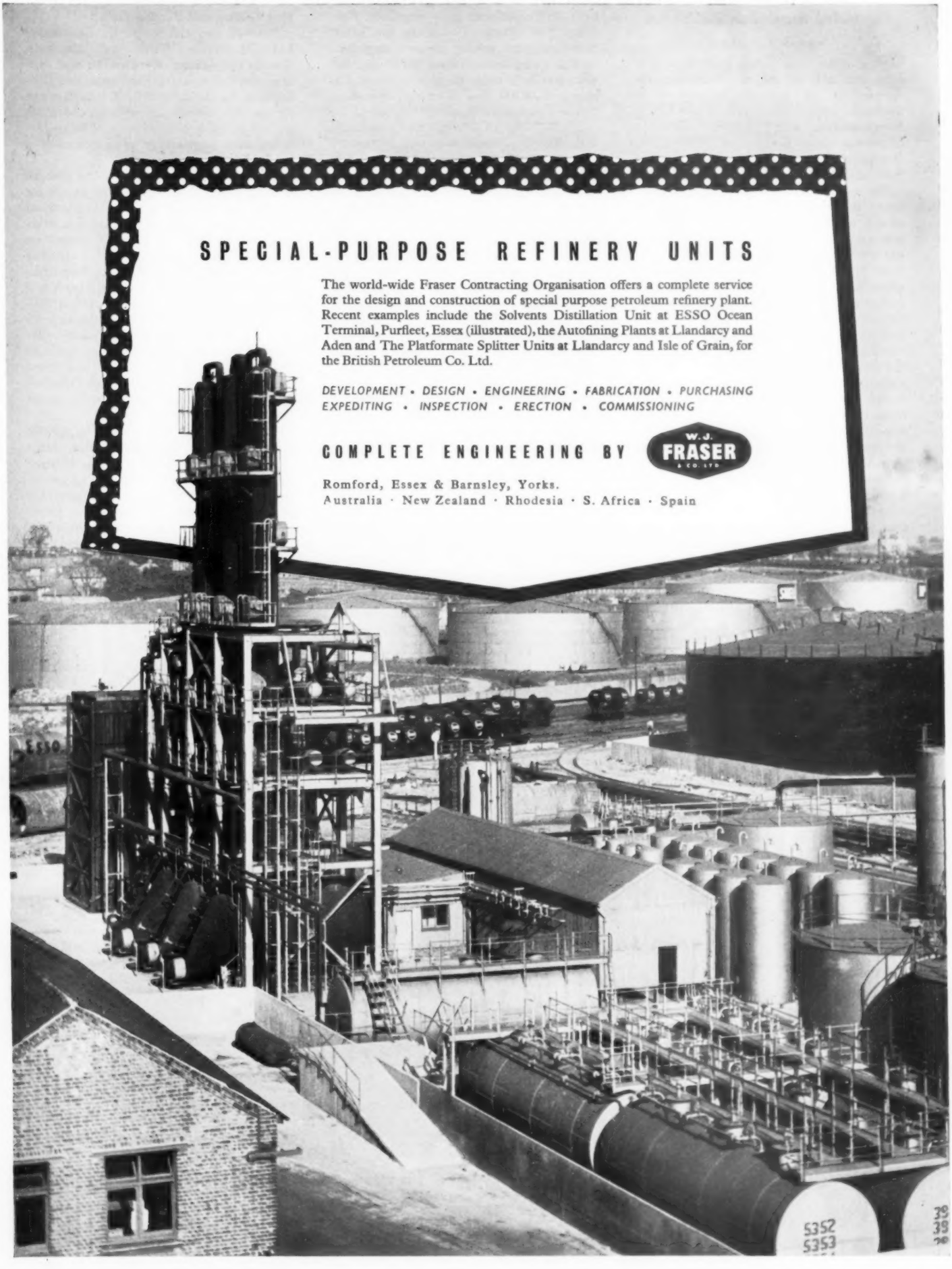
R. A. van Nordstrand (2,754,272 to Sinclair Ref. Co.) discloses a method of regenerating silica-magnesia catalyst by combustion of carbonaceous matter at 1 atmosphere abolute presure and at a steam partial pressure of 3-7 p.s.i.a. Two Texas Co. patents deal with catalyst regeneration. In 2,758,978 D. K. Beacon subjects the gaseous effluent from a fluid cat. cracker regeneration zone, containing catalyst fines, to cyclonic separation. An overhead stream, free of fines, and constituting 80-90% of the gaseous effluent is vented. The bottom stream, containing fines and 10-20% of the gases is subjected to electrostatic precipitation. A. R. Van der Ploeg in 2,760,913 regenerates metal contaminated catalysts at temperatures below 1125° in the presence of not over 10% steam. After the catalyst selectivity drops, a metal-free feed is used and the regeneration step is carried out at 1150°F with 50% steam, causing metals deactivation and an increase in catalyst density. W. H. Mattox in Esso Res. & Eng. Co.'s 2,742,405 avoids metal contamination of catalysts, by contacting freshly regenerated catalyst with a relatively small amount of an oil of low contaminated content before contacting it with the contaminated feed.

5. *Miscellaneous.* A combination catalytic cracking, thermal cracking and coking process is described in The M. W. Kellogg Co.'s 2,745,794 (N. J. G. Alozery and W. P. Given). A. W. Langer, Jr. (2,772,214 to Esso Res. & Eng. Co.) catalytically cracks a virgin gas oil and separates and partially hydrogenates products, boiling above 400°F. The hydrogenated product is subjected in liquid phase to hydrogen donor diluent cracking conditions in the absence of a catalyst. C. E. Jahnig in another Esso patent (2,735,802) claims methods and an apparatus for controlling the temperature of finely divided solids in fluidized beds.

W. J. Mattox in Esso's 2,742,518 selectively hydrogenates diolefins and acetylenes in naphthas from fluid coking in the presence of a naphtha rich in naphthene and over a chromite catalyst. A process for cracking petrolatum to high yields of C_3-C_{18} ole fins, which are principally straight chain or highly branched α-olefins is disclosed in Esso's 2,736,685 (H. L. Wilson, F. W. Banes, B. I. Smith and J. F. Nelson).

A Sinclair Ref. Co. patent (2,759,877, A. H. Evon) is concerned with the electrostatic separation of a suspension of finely divided solid particles in a gaseous stream.

Production of ethylene and aromatics rich in benzene and toluene from a C_3 fraction is the subject of The Texas Co.'s 2,735,876 (H. V. Hess and N. D. Carter). The charge is introduced to nickel-free chrome steel tubes at a pressure below 50 psig and heated to 1350-1550° F. The tubes have an area to volume relationship of above 200 ft^2/ft^3, and residence time in the tube is 0.5-2 seconds. END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Expanded Australian Refineries

(Continued from page 93)

closing of the Suez Canal, when New Zealand was able to call on Australian refineries for an increased portion of its needs. In the past two years, Australia has been supplying quite significant quantities of petroleum products to New Zealand; and it could well be that, when production permits, shipments will grow.

The extent to which the Australian refining industry is able to meet the needs of the nation is shown in Table I, which sets out refinery production for 1956 against the over-all Australian demand.

At present, no refinery has large-scale plans for expansion of output. They are rather engaged in eliminating bottlenecks, following the initial establishment which enables more efficient use to be made of residuals. BP Refinery (Kwinana) Ltd., has the largest project on hand, with the installation of a catalytic reformer at an estimated cost of £3,500,000. This will enable more high-octane motor spirit to be produced and permit the refinery to blend a greater number of products. The Shell Co.'s refinery at Clyde, NSW, is being expanded by the addition of a Platformer and extensions of the crude-distillation unit. Capacity will be increased in 1958 to 800,000 tons per annum from present 500,000 tons.

Details of Australia's refineries are set out as follows:

Australian Oil Refining Pty. Ltd., Kurnell, NSW—Refinery came onstream, February 1956. Plant: Two-stage distillation, fluid catalytic cracking, propane decarbonization, and polymerization units—together with auxiliary units to operate these. Capacity, 1,500,000 tons of crude per annum. Crude comes from Sumatra.

BP Refinery (Kwinana) Ltd., Kwinana, WA—Refinery came onstream, February 1155. Plant: Atmospheric and vacuum distillation, catalytic cracking, reforming, and desulfurization units, as well as ancillary treatment units. Capacity, 3,000,000 tons of crude per annum. Crude oil comes from the Persian Gulf.

Shell Refining (Australia) Pty. Ltd., Geelong, Victoria—Refinery came onstream, March 1954. Plant: Atmospheric and vacuum distillation, catalytic cracking, polymerization, Platforming, and ancillary units. Capacity 2,200,000 tons of crude per annum. Crude comes from British Borneo and Persian Gulf.

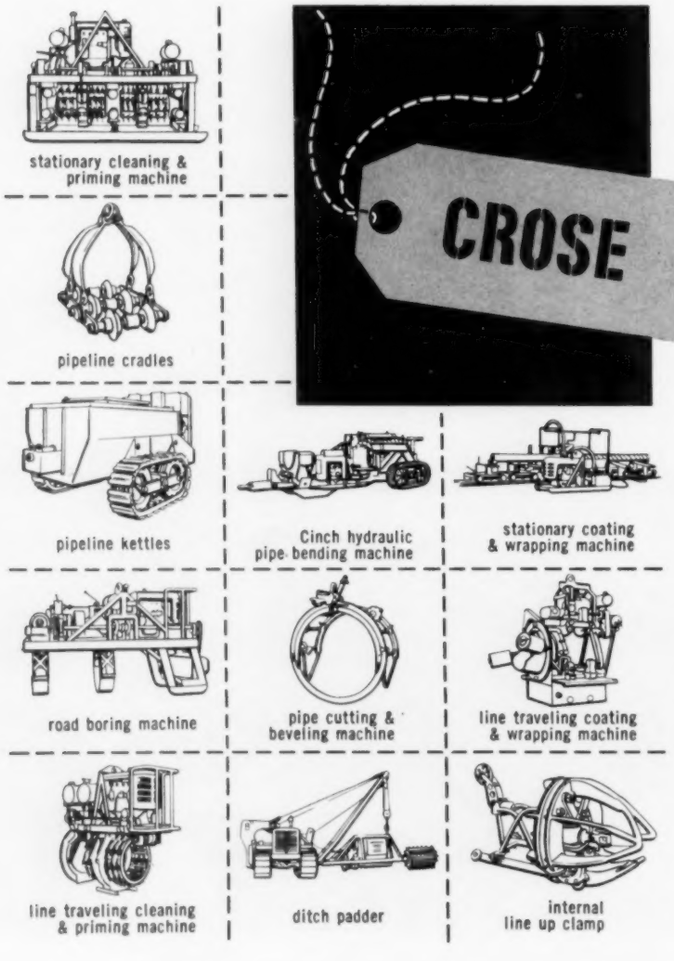
Clyde NSW refinery: Capacity, 500,000 tons of crude. Crude-distillation unit is being extended, and Platformer is in course of construction, which will lift capacity to 800,000 tons per annum. Crude comes from British Borneo.

Standard-Vacuum Refining Co. (Australia) Pty. Ltd., Altona, Victoria—Expanded refinery came onstream, January 1955. Plant: Atmospheric and vacuum distillation, catalytic cracking, reforming and alkylation units. Capacity, 1,500,000 tons of crude per annum. Crude comes from West New Guinea and Persian Gulf.

Bitumen and Oil Refineries (Australia) Ltd., Matraville, NSW, and Hamilton, Queensland—Plant: Atmospheric and vacuum distillation units, Platformer and Unifining units. Capacity, 600,000 tons of crude per annum. Installation of a second Platformer and second Unifiner will be undertaken soon, preparatory to an extension of crude-distillation plant.

Australia's one great lack is the absence of indigenous oil resources. The search for oil proceeded at a good tempo, but without success, since a strike was made in a wildcat well by West Australian Petroleum Pty. Ltd., in November 1953. California Texas Corp., of the USA, has a four-fifths holding in West Australian Petroleum and one-fifth interest is held by Ampol Exploration Ltd., an Australian company. In the past three years, it is officially estimated that £28 million has been spent in the search for oil in Australia and territories. In Western Papua, the BP-Vacuum-Oil Search group alone will spend £4,500,000 this year.

Finding oil in commercial quantities would give Australia a completely integrated oil industry, without having to draw on outside sources for supplies of crude. Such a discovery would be of incalculable benefit to Australia; but, until oil is found in commercial quantities, the industry is likely to work steadily towards making the country wholly self-sufficient in refining capacity for its petroleum needs. END



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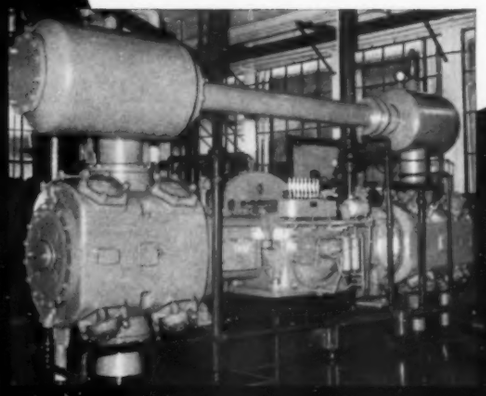

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OIL REFINERIES OF THE WORLD

The tabulation below has been prepared to show the present capacities and status of oil refineries outside the United States where such information is available. No data is given on U.S.S.R. plants or refineries in nations dominated by the Russians. Capacities are barrels per day. Key to type of plant: S—Skimming; L—Lubricating; A—Asphalt; C—Cracking; Comp.—Complete. Under cracking capacity to indicate type: T—Thermal; C—Catalytic.

SUMMARY OF REFINERY CAPACITIES

Operating or Operable Capacities July 1, 1957

Country	No. of Plants	Crude Capacity Barrels Daily	Cracking Capacity Barrels Daily
Aden	1	120,000	—
Albania	3	3,400	—
Argentina	16	216,670	113,340TC
Australia	6	204,000	56,500C
Austria	9	47,410	11,000T
Bahrain Island	1	186,500	36,700TC
Belgium	8	152,300	30,500TC
Bolivia	4	11,900	—
Brazil	8	111,800	16,400T
British Borneo	1	50,000	—
Bulgaria	3	9,000	—
Burma	2	6,500	—
Canada	43	704,350	352,825TC
Chile	4	20,360	16,000T
China	4	18,000	—
Colombia	4	73,000	44,760TC
Cuba	5	53,675	3,300C
Czechoslovakia	4	26,000	—
Denmark	3	980	—
East Germany	2	4,800	—
Ecuador	2	5,650	—
Egypt	3	74,000	6,500T
Formosa	1	28,000	14,000TC
France	15	628,470	119,450TC
Germany	29	335,010	80,300TC
Greece	1	27,000	—
Hawaiian Islands	1	3,000	—
Hungary	4	24,000	—
India	4	101,900	18,600TC
Indonesia	5	230,300	44,500T
Iran	2	463,000	102,000TC
Iraq	4	45,630	18,000T
Israel	1	87,000	23,500T
Italy	35	550,500	68,320TC
Japan	22	410,300	32,800TC
Kuwait	1	30,000	—
Lebanon	2	20,500	—
Mexico	8	340,000	46,500TC
Netherlands	2	341,000	95,000TC
Netherlands West Indies	2	650,000	460,000TC
Norway	1	1,800	—
Pakistan	1	5,000	—
Peru	3	46,000	14,500T
Philippine Islands	1	13,000	5,400C
Poland	7	12,000	—
Portugal	1	27,000	10,000C
Puerto Rico	2	65,500	58,000C
Romania	15	157,000	69,000TC
Saudi Arabia	1	189,000	—
South Africa	2	20,000	7,700TC
Spain	3	115,700	3,500T
Sweden	4	47,900	1,000T
Switzerland	2	1,850	—
Trinidad	3	127,000	48,000TC
Turkey	1	7,000	3,000C
United Kingdom	16	618,150	127,300TC
USSR	68	1,800,000	520,000TC
United States	320	8,922,000	5,100,000TC
Uruguay	1	28,000	7,000TC
Venezuela	11	612,100	88,000T
Yugoslavia	3	19,800	1,100T
Totals		**19,251,705**	**7,870,975**
Western Hemisphere		11,988,005	6,368,625
Eastern Hemisphere		7,263,700	1,500,350

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Aden:				
BP Refinery (Aden) Ltd.	Little Aden (1)	120,000	S	—
(1) 12,000 b/d catalytic reforming capacity. Under construction: thermal reformer, complete 1958.				
Albania:				
Cerzic	Tirana-Eibassan	3,000	SLA	—
There are reported to be two other small plants with a combined capacity of 400 b/d.				
Argentina:				
Cia General Asfaltos	Wilde (B.A.)	370	L	—
Esso Refinadora de Petroleo	Campana (B.A.)	37,000	Comp.	15,000T
	Bahia Blanca (B.A.)	7,500	CS	45,000T
	Manuel Elordi (Salta)	1,350	S	—
	Dadin (P. Huincol)	500	S	—
Condor	Lomas de Zamora (B.A.)	800	SL	—
Diadema Argentina S.A. de Petroleo	Buenos Aires (1)	23,000	Comp.	9,000T
La Isaura	Bahia Blanca (2)	1,800	SC	1,000T
Loterro y Papini	Avellaneda (B.A.)	800	SL	—
Ragor S.A.	Quilmes (B.A.)	300	SL	—
Y.P.F. (Ende)	Dock-Sud Avellaneda (B.A.)	5,500	Comp.	3,000T
	La Plata (3)	100,000	Comp.	56,000TC
	San Lorenzo (Santa Fe)	17,000	SC	13,000T
	Lujan de Cuyo (Mendoza) (4)	11,900	SC	9,000T
	Chachapoyas (Salta)	2,500	SC	1,300T
	Plaza Huincul (Nequen)	1,550	SC	540T
Petroquimica (E.N.)	Comodora Rivaidavia	4,800	SC	1,500T
(1) 3,000 b/d catalytic reforming capacity.				
(2) 2,500 b/d tube still plant under construction.				
(3) 18,400 b/d fluid catalytic cracking capacity and 7,000 b/d thermal cracking capacity.				
(4) 28,000 b/d crude still completion 1958.				
Australia:				
Australian Oil Ref. Ltd.	Kurnell, NSW (1)	1,000	SC	13,000C
Bitumen & Oil Refineries Ltd.	Sydney (2)	13,500	SA	—
	Hamilton	2,000	SA	—
BP Refining (Kwinana) Ltd.	Kwinana (3)	70,000	SC	12,500C
Shell Ref. Pty. Ltd. (Aus.)	Clyde (4)	10,000	SLA	—
Shell Ref. Pty. (Aus.)	Geelong (5)	45,000	SC	13,000C
Standard Vacuum Refining Co. (Australia) Pty. Ltd.	Altona (6)	32,500	SLA	18,000C
(1) 5,500 b/d propane decarbonization capacity and 1,500 b/d polymerization capacity.				

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BURTON'S PATENT PUTLOG COUPLER
For fixing Putlogs or Transoms to Horizontal Tubes.

BURTON'S PATENT DOUBLE COUPLER
For Coupling Upright Tubes to Horizontal Tubes.

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(2) 2,300 b/d Platforming and 2,300 b/d Unifing capacity, 5,000 naphtha Unifiner, under construction: completion 1957.
(3) 6,000 b/d Platformer; 5,600 b/d desulfurization to be completed end 1958.
(4) 11,000 b/d Hydrodesulfurizer projected for 1959 completion.
(5) 6,700 b/d catalytic reformer; to be completed 2nd quarter 1958; 2,800 b/d cat poly.
(6) 6,000 b/d Sovaformer; 1,600 b/d alkylation unit.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Austria:				
A.G. der Shell	Florisdorf	4,000	Comp.	—
Mobil Oil (Austria) A.G.	Kagran	4,500	SLA	—
Richard K. van Sickle	Neuseidl/Zaya	360	S	—
Oesterreichische Mineral-oelwerke	Kledering	150	SL	—
	Voesendorf	2,300	SLA	—
	Korneuburg	7,000	SLA	—
	Schwechat	13,300	Comp.	5,000T
	Lobau	8,800	S	—
	Moosbierbaum	7,000	SC	6,000T

Note: Plants are listed according to present management. Nationalization of Shell and Mobil refineries has been proposed but suspended. Others except the van Sickle plant built in 1956 are now managed by OeMV.

Bahrain Island:				
Bahrain Petroleum Co.	Bahrain, Persian Gulf (1)	210,000	SCA	36,700TC

(1) 19,500 b/d thermal reforming capacity, 15,700 b/d thermal cracking capacity and 21,000 b/d catalytic cracking capacity. Under construction: 10,000 b/d Platformer; complete 1957.

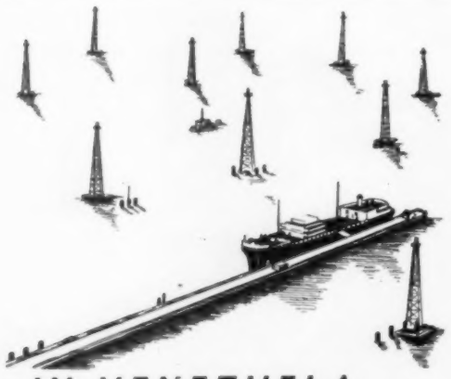
Belgium:				
"Albatros" S.A. Belge pour le Raffinage de Petrole	Antwerp, Kiel (1)	14,000	SC	4,500C
Belgian Shell Co. S.A.	Ghent	3,000	SLA	—
Compagnie Industrielle "Atlas" S.A. (Esso)	Hoboken-Antwerp	2,500	S	—
Esso Standard Ref. S.A.	Antwerp (2)	33,000	SC	11,000C
Raffineries Belge des Petroles	Antwerp (3)	16,300	SC	4,000T
Raffineries et Distilleries Anversoise S.A. "Radain"	Antwerp	3,500	S	—
Soc. Industrielle Belge des Pet.	Antwerp (4)	75,000	SCA	11,000C
Tankage et Transport S.A.	Antwerp (5)	5,500	S	—

(1) Catalytic polymerization unit.
(2) 4,000 b/d thermal reforming capacity, 5,000 b/d cat reformer and 6,000 b/d Hydrofiner for completion July 1958.
(3) 2,300 b/d catalytic reformer and 2,400 b/d thermal reforming capacity. New topping unit and gas oil desulfurization plant under construction. Asphalt facilities of 150,000 tons yearly capacity.
(4) A 10,000 b/d Hydrofiner and 10,000 b/d cat reformer under construction; completion early 1958. Topping unit revamp to increase crude capacity to 90,000 b/d. Present thermal reforming capacity 6,000 b/d.
(5) 750 b/d Platforming capacity.

Bolivia:				
Yacimientos Petroliferos Fiscales Bolivianos	Cochabamba (1)	6,000	S	—
	Sucre	4,000	S	—
	Camiri	1,500	S	—
	Sanandita	400	S	—

(1) 1,500 b/d Platformer under construction.

Brazil:				
Companhio de Petroleo da Amazonia	Manaus	5,000		
Distillaria Riograndense de Petroleo S.A.	Uruguaiana Rio Grande do Sul	300	S	—
Industrias Matarazzo de Energia S.A.	Sao Paulo	500	S	—
Petroleo Brasileiro S.A. (Petrobras)	Mataripe (1)	5,000	SC	3,000T
	Cubatao Presidente Bernades (2)	65,000	SC	8,000T
Piranga S.A. Cia Brasileira de Petroleo	Rio Grande do Sul	6,000	SCA	2,000T
Refinaria e Exploracao de Petroleo Uniao	Sao Paulo (3)	20,000	S	—
Refinaria de Petroleo de Manguinhos	Rio de Janeiro	10,000	S	3,400T



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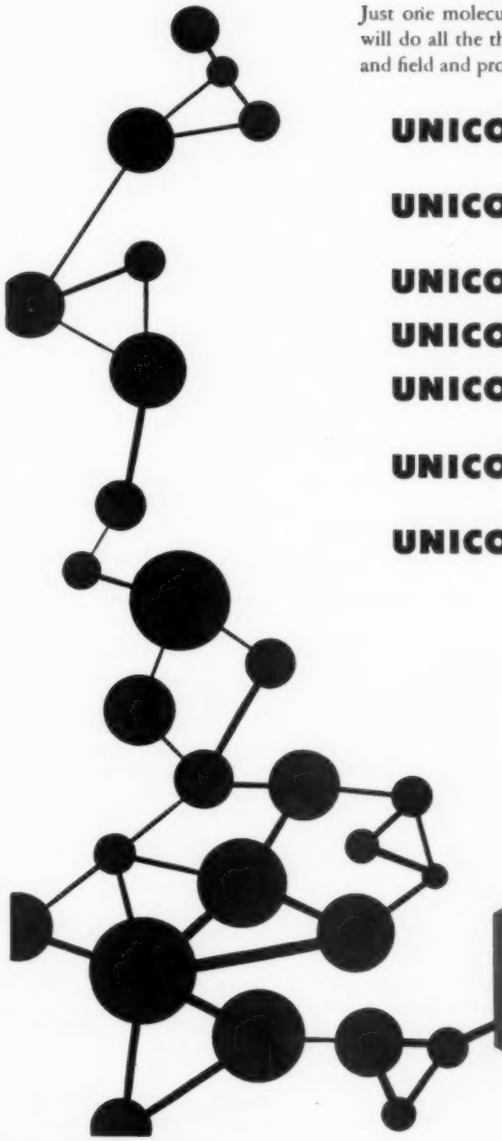

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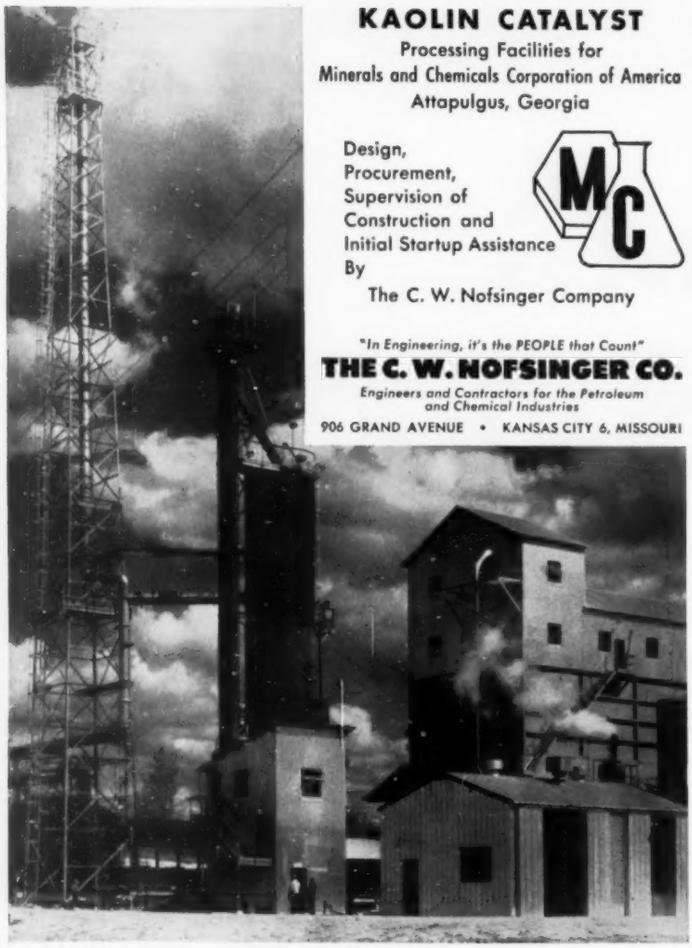

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(1) Under construction: Crude capacity to be increased to 37,000 b/d, 2,800 b/d lube plant; complete early 1958.

(2) 116,000 tons/year asphalt capacity. Under construction: Crude capacity to be increased to 90,000 b/d. Current crude runs 72,000 b/d. Ethylene recovery unit to be completed 1957. Fertilizer plant 340 t/d operating.

(3) Actually processing 31,000 b/d.

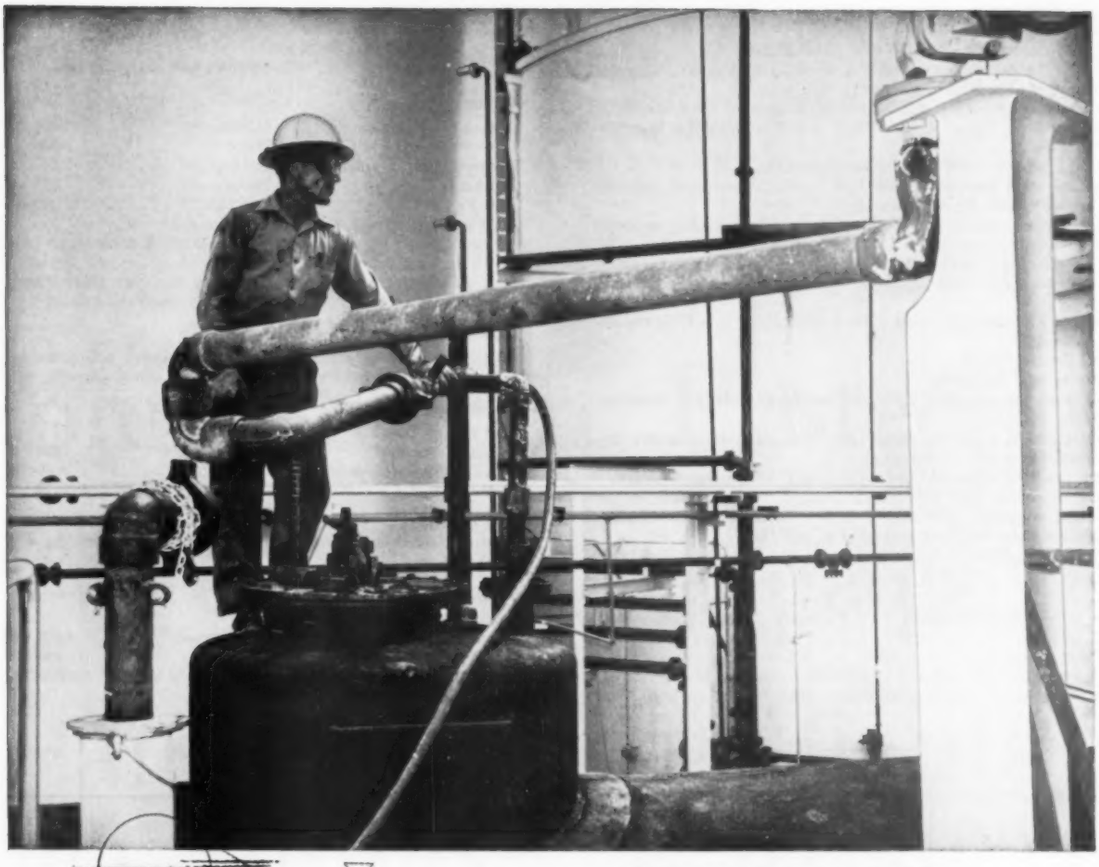
Note: Petrobras to build 80,000 b/d refinery in Federal District and two other refineries at undisclosed locations.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
British Borneo:				
Sarawak Oilfields Ltd.	Lutong, Sarawak	50,000	S	—
Bulgaria:				
In the absence of official information, recent estimates indicate 3 refineries in operation in Bulgaria with a daily capacity of 9,000 barrels.				
Burma:				
Burmah Oil Co. (1954) Ltd.	Chauk	3,000	S	—
	Syriam	3,500	S	—
Chile:				
Johannsen, G. H.	Coquimbo	125	S	—
Maritano, Miguel	Talcahuano	60	S	—
Soc. Establecimientes Quimicos	Via del Mar	175	S	—
Empresa Nacional del Petroleo	Concon (1)	20,000	SC	16,000T

(1) 4,600 b/d thermal reforming capacity to be revamped as 8,00 b/d crude unit. For 1959 completion construction includes 30,000 b/d added topping, 12,000 b/d cat cracking and 6,000 b/d cat reforming.

Canada:				
Anglo-Canadian Oil Ltd.	Brandon, Man. (1)	3,100	SC	1,225T
Anglo-American Exp. Ltd.	Hartell, Alta. (2)	4,000	SC	1,500T
Bonnyville Oil Refineries	Bonnyville, Alta.	1,000	S	—
British American Oil Co. Ltd.	Calgary, Alta. (3)	7,200	SC	2,500T
	Edmonton, Alta. (4)	7,000	SC	3,400C
	Moose Jaw, Sask.	15,000	SCA	6,000TC
	Clarkson, Ont. (5)	21,500	Comp.	16,100TC
	Montreal, Que. (6)	45,000	SCA	19,250C
Canadian Oil Refineries Ltd.	Sarnia, Ont. (7)	30,000	SC	13,000C
Canadian Petrofina	Montreal, Que. (8)	20,000	Comp.	16,000C
Consumer's Co-operative Ref.	Regina, Sask.	16,000	SCA	8,000TC
Excelsior Refineries Ltd.	Lloydminster, Alta.	3,500	SA	—
Husky Oil & Ref. Ltd.	Lloydminster, Alta.	8,500	SA	—
	Ft. Williams, Ont. (9)	4,000	SA	—
	Moose Jaw, Sask. (10)	3,000	SA	—
Imperial Oil Limited	Montreal, Que. (11)	65,000	SCA	29,500TC
	Halifax, N.S. (12)	42,000	Comp.	38,700TC
	Sarnia, Ont. (13)	78,000	Comp.	23,300TC
	Winnipeg, Man. (14)	15,000	SCA	6,400C
	Regina, Sask. (15)	22,500	SCA	12,550TC
	Edmonton, Alta. (16)	25,000	Comp.	22,900TC
	Calgary, Alta.	9,200	SCA	4,600T
	Vancouver, B.C. (19)	25,000	SCA	11,800C
	Norman Wells, NWT	1,250	S	—
McColl-Frontenac Oil Co. Ltd.	Montreal E. Que. (17)	55,000	SC	32,500TC
	Edmonton, Alta. (18)	11,500	SC	5,800TC
New Brunswick Oilfields Ltd.	Weldon, N.B.	300	S	—
Northern Petroleum Corp. Ltd.	Kamsack, Sask.	800	S	—
North Star Oil Ltd.	St. Boniface, Man.	12,000	SC	5,100C
	Grand Prairie, Alta.	2,500	SC	1,100T
Prince Albert Refineries Ltd.	Prince Albert, Sask.	1,000	S	—
Petroleum Fuels Ltd.	Moose Jaw, Sask.	1,000	S	—
Royalite Products Ltd.	Kamloops, B.C. (20)	5,000	SA	1,400
	Coleville, Sask.	5,000	SA	—
Radio Oil Refineries Ltd.	East Kildonan, Man. (21)	2,000	S	—
Royalite-Hiway Ltd. (Royalite Oil Co.)	Saskatoon, Sask.	6,500	SCA	7,660TC
Shell Oil Co. of Canada Ltd.	Shellburn, B.C. (22)	20,000	Comp.	10,100TC
	Montreal East (23)	60,000	Comp.	28,500TC
Standard Oil Co. of B.C. Ltd.	N. Burnaby, B.C. (24)	16,000	SC	9,000C
Sun Oil Co.	Sarnia, Ont. (25)	15,000	SC	11,000C
Regent Refining (Canada)	Port Credit, Ont. (26)	14,000	SC	4,000TC
Wainright Refineries Ltd.	Wainwright, Alta.	3,000	S	—
XL Refineries	Dawson Creek, B.C.	2,000	SC	—

(1) 1,200 b/d Platforming capacity.
(2) 1,000 b/d catalytic reforming capacity.
(3) 2,000 b/d catalytic reforming capacity.



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(6) 16,000 b/d catalytic cracking capacity and 13,000 b/d catalytic reforming capacity. A 15,500 b/d catalytic desulfurization unit.
(7) 4,500 b/d Platforming capacity, catalytic cracking capacity to 13,000 b/d.
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(13) 4,000 b/d thermal cracking capacity, 19,300 b/d catalytic cracking capacity, 13,500 b/d Powerformer.
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(16) 9,100 b/d thermal cracking capacity, 12,800 b/d catalytic cracking capacity and 2,000 b/d Powerforming capacity.
(17) 12,500 b/d thermal cracking capacity, 20,000 b/d catalytic cracking capacity, 11,000 b/d catalytic reforming capacity, 10,000 b/d hydrotreating under construction.
(18) 3,100 b/d thermal cracking capacity and 2,700 b/d catalytic cracking capacity. 3,000 b/d Platformer.
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(20) 3,500 b/d Platforming and Unifining.
(21) 3,500 b/d thermal cracking capacity, 6,600 b/d catalytic cracking capacity, 3,300 b/d Platforming capacity.
(22) 9,000 b/d thermal cracking capacity, and 19,500 b/d catalytic cracking capacity, 6,600 b/d Platformer, 600 T/D Asphalt.
(23) 9,000 b/d catalytic cracking capacity and 2,750 b/d Platforming capacity.
(24) 11,000 b/d catalytic cracking, 3,000 b/d Houdriformer.
(25) 2,300 b/d Platforming capacity, 7,000 b/d catalytic cracking capacity building, 6,000 b/d crude capacity building, completion late 1957.
(26) 750 b/d thermal cracking, 500 b/d catalytic reforming.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
China:				

It is estimated that 4 operating plants have a combined capacity of 18,000 b/d. A 20,000 b/d plant is building at Yuman; completion 1958-59.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Colombia:				
Colombian Petroleum Co.	Tibu	8,000	S	—
International Petroleum (Colombia) Ltd.	Barrancabermeja (1)	37,500	Comp.	31,630TC
	Cartagena (2)	26,500	SC	13,130C
The Texas Petroleum Co.	Guamo	1,000	S	—

(1) Plant owned by Empresa Columbiana de Petroles. Operated under contract by International Petroleum.
(2) Under construction; will be complete Aug. 25, 1957.

Cuba:				
Compania Petrolea (Shell)	Havana (1)	27,000	S	—
Esso Standard Oil Co.	Belot (2)	6,500	S	—
Refinadora Cabaiguan	Cabaiguan	2,000	S	—
Refineria Bacuranao	Bacuranao	175	S	—
The Texas Co.	Santiago (3)	20,000	S	3,300

(1) Plant includes 5,000 b/d catalytic reformer.
(2) Refinery being replaced by new 35,000 b/d plant, to be on stream end 1957. Includes fluid cracking unit, Hydroforming and Hydrofining units.
(3) Construction to be completed late summer 1957. Plant includes 3,300 b/d catalytic reformer and 4,100 b/d Hydrotreating unit.

Czechoslovakia:

In the absence of official information, recent estimates indicate a total of 4 refineries in Czechoslovakia with a daily crude capacity of 26,000 barrels.

Denmark:				
A/S Kalundborg Oileraffinaderi	Kalundborg	850	S	—
Dansk Mineraloliefabrik	Copenhagen	60	SLA	—
L. C. Glad & Co.	Copenhagen	70	S	—

East Germany:

It is estimated that two refineries in East Germany have a crude capacity of 4,800 b/d.

Ecuador:				
Anglo-Ecuadorian Oilfields Ltd.	La Libertad (1)	5,200	S	—
Manabi Exploration Co.	Cautivo	450	S	—

(1) 7,700 b/d distillation unit and 6,000 b/d UOP thermal cracker planned for completion July 1958.

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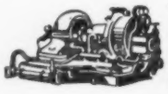

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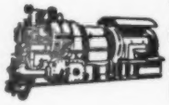

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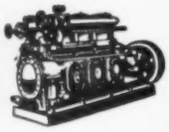

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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Egypt:				
Anglo-Egyptian Oil Fields Ltd.	Suez (1)	44,000	SCA	6,500T
Raffinerie de Petrole du Government	Suez (2)	20,000	SA	—
	Cairo (3)	10,000	S	—

(1) 4,000 b/d thermal reforming capacity. A 2,300 b/d Platformer is under construction; complete end of 1957.
(2) 20,000 b/d distillation unit is planned for construction.
(3) Will go on stream end of 1957.

Finland:

Neste Corp. is building a 18,000 b/d refinery at Turku.

Formosa:

Chinese Petroleum Corp.	Kaoshiung Taiwan (1)	28,000	SA	14,000TC

(1) 4,000 b/d visbreaking capacity, 10,000 b/d catalytic cracking capacity and 3,100 b/d thermal reforming capacity, 850 b/d alklyation unit and 10 t/d sulfur unit planned for completion June 1958.

France:

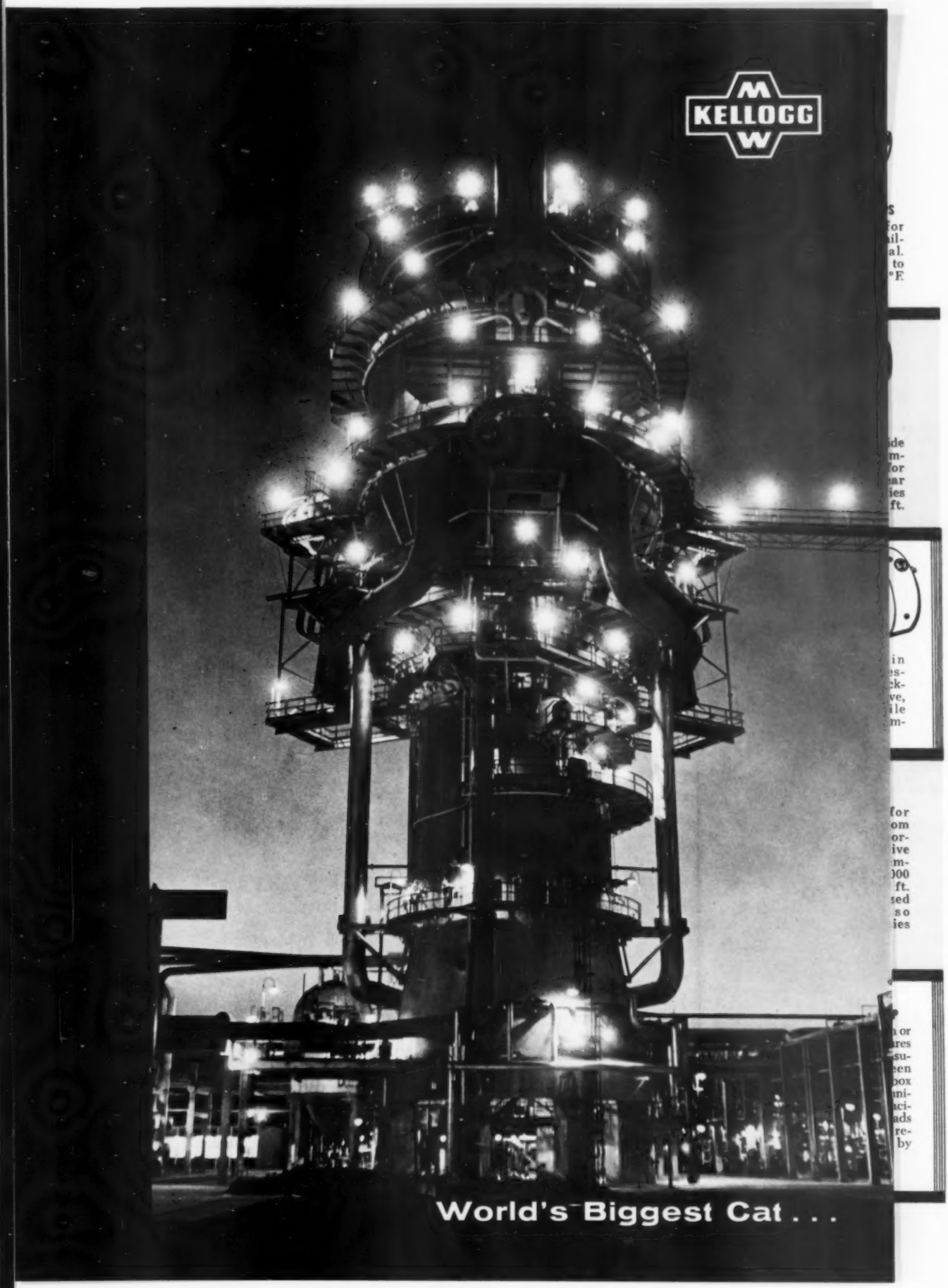
Compagnie Francaise de Raffiinage	La Mede (1)	130,000	SAC	14,000TC
	Gonfreville (2)	70,000	Comp.	28,500TC
Compagnie de Raffinage Shell-Berre	Petit-Couronne (3)	50,000	Comp.	12,500C
	Pauillac	16,500	SA	—
	Berre (4)	75,000	Comp.	14,700TC
Pechelbronn SAEM	Merkwiller	4,200	SAL	—
Raffineries Francaises de Petrole de L'Atlantique	Donges (5)	34,000	Comp.	20,400C
Caltex SAF	Bec d'Ames (6)	22,000	SC	4,800C
Ste. Cherifienne des Petroles	Petitjean (Morocco)	4,000	SC	2,650C
Ste. Francaise des Petroles B.P.	L'Avera (7)	45,000	S	—
	Dunkerque (8)	47,000	Comp.	—
Mobil Oil Francaise	N. Dame de Gravenchon (9)	17,000	SL	—
	Frontignan (10)	28,000	SC	10,900C
Esso Standard Societe Anonyme Francaise	Port Jerome (11)	85,000	Comp.	11,100C
	La Mailleraye (12)	770	L	—

(1) 18,000 b/d thermal reforming capacity, 2,000 b/d thermal cracking capacity and 12,000 b/d catalytic cracking capacity.
(2) 13,000 b/d thermal reforming capacity, 9,000 b/d thermal cracking capacity and 30,000 b/d catalytic cracking capacity.
(3) New distillation unit of 80,000 b/d projected for completion 3rd quarter 1958. Catalytic reformer 13,000 b/d projected for completion 1st quarter 1959.
(4) 11,000 b/d cat cracking, 4,700 b/d thermal capacity.
(5) 4,000 b/d thermal reforming capacity. Under construction: 11,000 b/d Houdriformer.
(6) Under construction: Vacuum unit, FCCU and poly plant; complete 1957. Thermal Reforming capacity 3,900.
(7) 5,500 b/d thermal reforming capacity. Under construction: 50,000 b/d topping plant, complete end 1957.
(8) 7,300 b/d thermal reforming capacity, 10,000 b/d cat. reformer under construction completion mid 1958.
(9) 2,500 b/d thermal reforming capacity and 3,500 b/d catalytic reforming capacity.
(10) 2,500 b/d thermal reforming capacity.
(11) 12,000 b/d thermal reforming capacity. Under construction: 10,000 b/d catalytic cracker; complete 1957.
(12) Medicinal and technical white oil greases and special products.

Germany:

Badische Anilin- und Soda-Fabrik AG.	Ludwigshafen-on-Rhine	1,000	SL	—
BP Benzin- und Petroleum-GmbH. (British Petroleum Co. Ltd.)	Hamburg-Finkenwerder (1)	32,000	SCA	4,500T
Deutsche Erdoel-AG.	Heide (14)	18,000	Comp.	8,000C
	Wietze	1,000	SLA	—
	Hamburg-Grasbrook (2)	1,600	L	—
Deutsche Shell AG.	Hamburg-Harburg (3)	19,000	Comp.	—
	Monheim/Reisholz	4,700	SCAL	—
	Hamburg-Grasbrook (2)	640	L	—
Esso AG.	Hamburg-Harburg (4)	47,000	Comp.	10,100C
Gelsenberg Benzin AG.	Gelsenkirchen (5)	67,000	SCH	10,000C
Gewerkschaft Deurag-Nerag	Misburg nr. Hanover (6)	16,000	SCL	5,000T
Gewerkschaft Erdoel-Raffinerie Emsland	Lingen in Emsland (7)	16,000	SC	18,000C

(Continued on page 144)

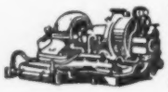

KELLOGG
World's Biggest Cat . . .

BROTHERHOOD

VERTICAL AND HORIZONTAL

STEAM TURBINES

FOR DRIVING PUMPS, ETC.



Wide range—All types.
Over 50 years' experience.
Hundreds in hand — thousands in service.

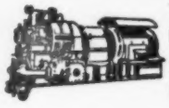
BROTHERHOOD

COMPRESSORS

Air, Gas and Refrigerating.
The widest range in the British Empire — made to suit your requirements.
Thousands in service.

BROTHERHOOD

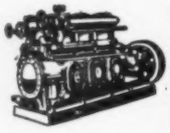
GENERATING SETS



Turbine driven up to 11,000 KW.
Engine driven up to 340 KW.
Scores in hand, hundreds in service.

BROTHERHOOD

REFRIGERATING PLANT



Ammonia, CO_2, Freon, Methyl Chloride, SO_2. Wide range — single and double acting — one or more stages. **Made to measure for special duties.**

also Manufacturers of all kinds of

PLANT TO CUSTOMERS' OWN DESIGNS

WHY NOT SEND YOUR PROBLEMS TO US?

We shall be pleased to investigate them confidentially without commitment

BROTHERHOOD
PETERBOROUGH ENGLAND
COMPRESSOR & POWER PLANT SPECIALISTS FOR NEARLY A CENTURY

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Egypt:				
Anglo-Egyptian Oil Fields Ltd.	Suez (1)	44,000	SCA	6,500T
Raffinerie de Petrole du Government	Suez (2)	20,000	SA	—
	Cairo (3)	10,000	S	—

(1) 4,000 b/d thermal reforming capacity. A 2,300 b/d Platformer is under construction; complete end of 1957.
(2) 20,000 b/d distillation unit is planned for construction.
(3) Will go on stream end of 1957.

Finland:

Neste Corp. is building a 18,000 b/d refinery at Turku.

Formosa:

Chinese Petroleum Corp.	Kaoshiung Taiwan (1)	28,000	SA	14,000TC

(1) 4,000 b/d visbreaking capacity, 10,000 b/d catalytic cracking capacity and 3,100 b/d thermal reforming capacity, 850 b/d alklyation unit and 10 t/d sulfur unit planned for completion June 1958.

France:

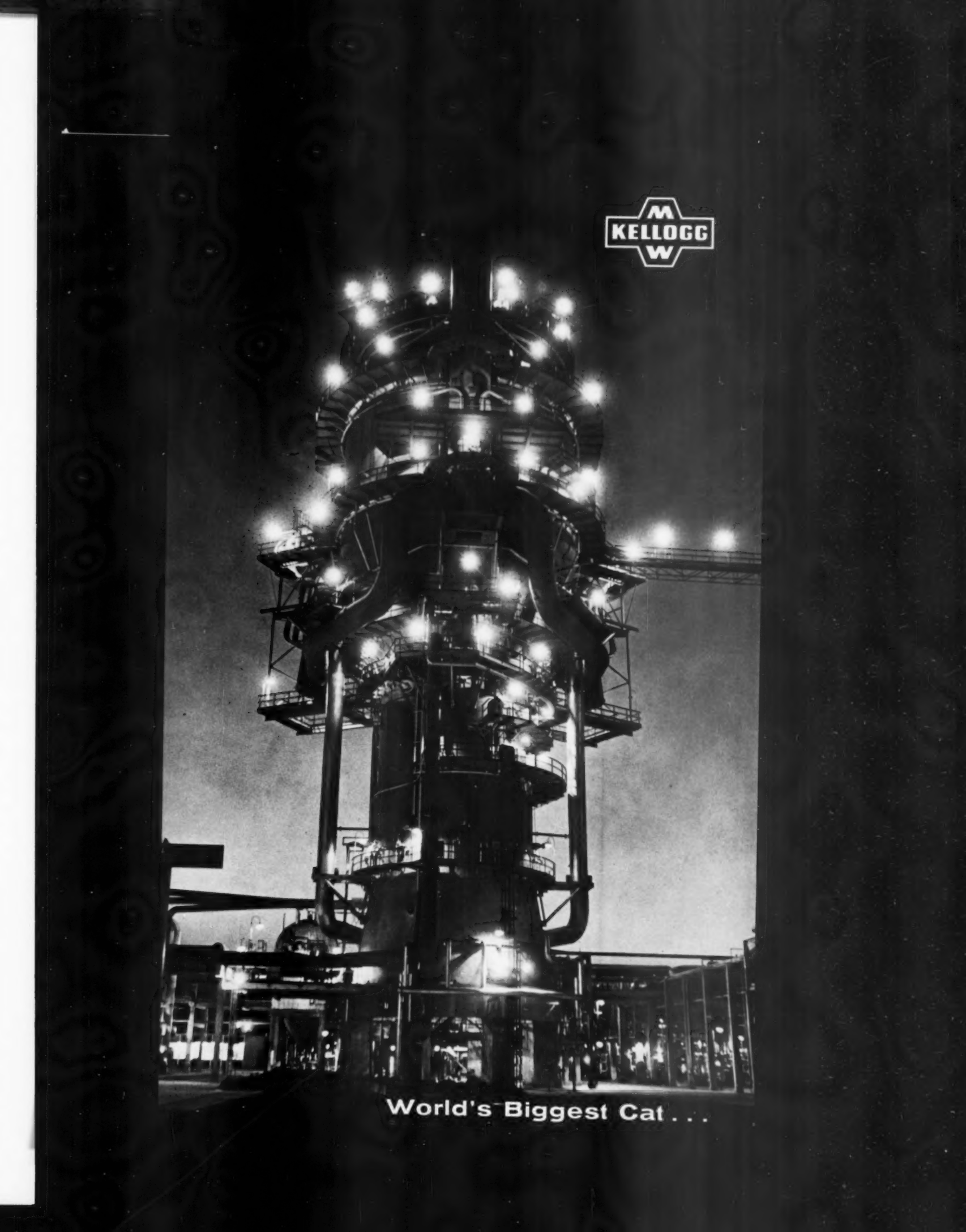
Compagnie Francaise de Raffiinage	La Mede (1)	130,000	SAC	14,000TC
	Gonfreville (2)	70,000	Comp.	28,500TC
Compagnie de Raffinage Shell-Berre	Petit-Couronne (3)	50,000	Comp.	12,500C
	Pauillac	16,500	SA	—
	Berre (4)	75,000	Comp.	14,700TC
Pechelbronn SAEM	Merkwiller	4,200	SAL	—
Raffineries Francaises de Petrole de L'Atlantique	Donges (5)	34,000	Comp.	20,400C
Caltex SAF	Bec d'Ames (6)	22,000	SC	4,800C
Ste. Cherifienne des Petroles	Petitjean (Morocco)	4,000	SC	2,650C
Ste. Francaise des Petroles B.P.	L'Avera (7)	45,000	S	—
	Dunkerque (8)	47,000	Comp.	—
Mobil Oil Francaise	N. Dame de Gravenchon (9)	17,000	SL	—
	Frontignan (10)	28,000	SC	10,900C
Esso Standard Societe Anonyme Francaise	Port Jerome (11)	85,000	Comp.	11,100C
	La Mailleraye (12)	770	L	—

(1) 18,000 b/d thermal reforming capacity, 2,000 b/d thermal cracking capacity and 12,000 b/d catalytic cracking capacity.
(2) 13,000 b/d thermal reforming capacity, 9,000 b/d thermal cracking capacity and 30,000 b/d catalytic cracking capacity.
(3) New distillation unit of 80,000 b/d projected for completion 3rd quarter 1958. Catalytic reformer 13,000 b/d projected for completion 1st quarter 1959.
(4) 11,000 b/d cat cracking, 4,700 b/d thermal capacity.
(5) 4,000 b/d thermal reforming capacity. Under construction: 11,000 b/d Houdriformer.
(6) Under construction: Vacuum unit, FCCU and poly plant; complete 1957. Thermal Reforming capacity 3,900.
(7) 5,500 b/d thermal reforming capacity. Under construction: 50,000 b/d topping plant, complete end 1957.
(8) 7,300 b/d thermal reforming capacity, 10,000 b/d cat. reformer under construction completion mid 1958.
(9) 2,500 b/d thermal reforming capacity and 3,500 b/d catalytic reforming capacity.
(10) 2,500 b/d thermal reforming capacity.
(11) 12,000 b/d thermal reforming capacity. Under construction: 10,000 b/d catalytic cracker; complete 1957.
(12) Medicinal and technical white oil greases and special products.

Germany:

Badische Anilin- und Soda-Fabrik AG.	Ludwigshafen-on-Rhine	1,000	SL	—
BP Benzin- und Petroleum-GmbH. (British Petroleum Co. Ltd.)	Hamburg-Finkenwerder (1)	32,000	SCA	4,500T
Deutsche Erdoel-AG.	Heide (14)	18,000	Comp.	8,000C
	Wietze	1,000	SLA	—
	Hamburg-Grasbrook (2)	1,600	L	—
Deutsche Shell AG.	Hamburg-Harburg (3)	19,000	Comp.	—
	Monheim/Reisholz	4,700	SCAL	—
	Hamburg-Grasbrook (2)	640	L	—
Esso AG.	Hamburg-Harburg (4)	47,000	Comp.	10,100C
Gelsenberg Benzin AG.	Gelsenkirchen (5)	67,000	SCH	10,000C
Gewerkschaft Deurag-Nerag	Misburg nr. Hanover (6)	16,000	SCL	5,000T
Gewerkschaft Erdoel-Raffinerie Emsland	Lingen in Emsland (7)	16,000	SC	18,000C

(Continued on page 144)


M
KELLOGG
W
World's Biggest Cat . . .

....Tidewater Oil Company's New

Orthoflow®

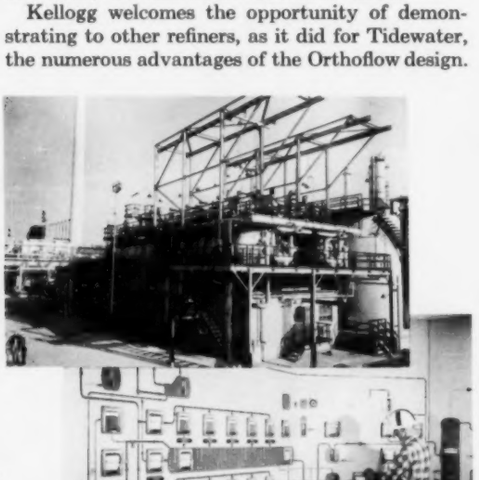
FLUID CATALYTIC CRACKER

developed and engineered

by The M. W. Kellogg Company

A throughput capacity of 102,000 BPD makes the Orthoflow Fluid Catalytic Cracking Unit, shown here and on the preceding page, the largest in the world. Engineered by The M. W. Kellogg Company for Tidewater Oil Company's Delaware Refinery, south of Wilmington, this Orthoflow is the culmination of Kellogg's experience in engineering 66 fluid catalytic cracking units throughout the world, of which 16 are Orthoflow units.

Kellogg welcomes the opportunity of demonstrating to other refiners, as it did for Tidewater, the numerous advantages of the Orthoflow design.



Kellogg Also Developed and Engineered Tidewater's Sulphuric Acid Alkylation Unit

With a design capacity of 5,000 BPD of alkylate, and a potential capacity of 9,000 BPD, Tidewater's alkylation unit at the Delaware Refinery is one of the largest in operation. Interior view shows controls for the two 5-stage reactors.

Refinery Process Division

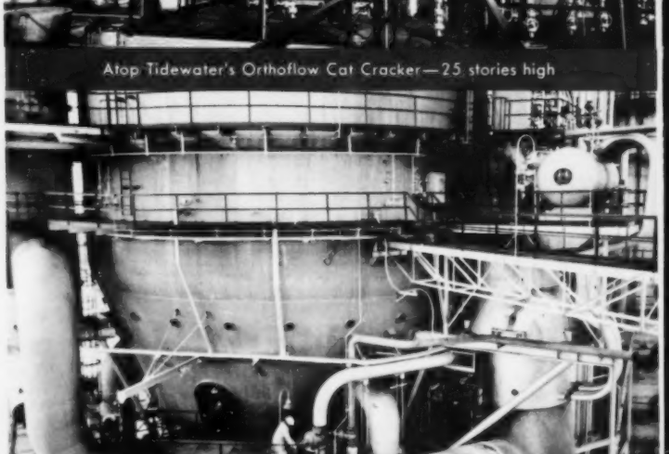
The M. W. Kellogg Company

711 Third Avenue, New York 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Co. Ltd., Toronto · Kellogg International Corp., London Kellogg Pan American Corp., New York · Societe Kellogg, Paris · Companhia Kellogg Brasileira, Rio de Janeiro · Compania Kellogg de Venezuela, Caracas

Atop Tidewater's Orthoflow Cat Cracker—25 stories high



Operator on platform of Orthoflow shows huge size of unit

Base of Orthoflow typifies its compact, functional design

BJ

pumps and mechanical seals for refineries

For special engineering assistance or for further information about Byron Jackson pumps and mechanical seals, contact your nearby BJ sales office or write Byron Jackson Pumps, Inc., P.O. Box 2017 Terminal Annex, Los Angeles 54, Calif.

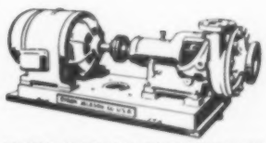
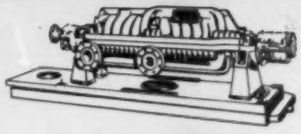


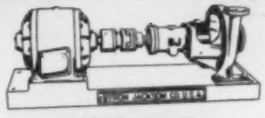
FIGURE 1025-1125 PROCESS PUMPS

Moderately priced pumps for general-purpose handling. Available with BJ Mechanical Seal. Capacities to 2000 gpm, heads to 800 ft. Temperature limit 350°F. Write for Bulletin 353-300.



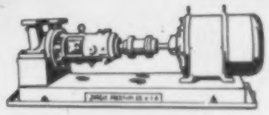
MULTIPLEX PUMPS

Recommended for boiler feed, debarking and all classes of medium-to-high pressure and temperature service. Easy inspection or cleaning without disturbing piping, bearings or driver.



CHEMICAL PUMPS

Specially engineered to handle corrosive liquids. Fitted with BJ Mechanical Seal with all major parts of seal isolated from pumped liquid. Positive protection against leakage to bearings or contamination of pumped liquid.



SM PROCESS PUMPS

For pumping fluids over a wide range of pressures and for temperatures up to 800° F. Ideal for pumping hot or cold liquids near their vapor pressure. Capacities to 4500 gpm and heads to 1900 ft.

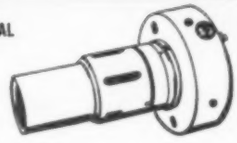
VERTICAL CIRCULATING PUMPS

Single or multi-stage. For pumping medium to high capacities of water. Capacities to 50,000 gpm. Saves space, simplifies piping. For dewatering, drainage, river intake, circulating and sump services.

SMI PROCESS PUMP

This general purpose pump features a BJ mechanical seal as a functional part of its design. It is built for continuous duty and temperatures to 400°F. Easily dismantled and reassembled without disturbing suction or discharge connections. Construction materials to suit application. Sizes: 1½ thru 6" suction, 1 thru 4" discharge. Capacities to 1500 gpm. Heads to 700 ft.

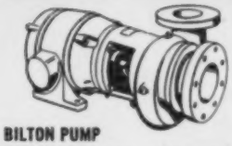
MECHANICAL SEALS



Replace standard packing in stuffingboxes. Eliminate excessive leakage and frequent repacking. Recommended for corrosive, high temperature or volatile liquid pumping. Prevent contamination of pumped liquid.

DOUBLE SUCTION HOT OIL PUMP

Developed for capacities beyond the range of single suction process pumps. Designed to handle high temperature liquids on continuous service operation. Rotating element can be removed as a unit without disturbing the piping or driver. Capacity range from 1000 to 7000 gpm, heads from 100 to 700 feet. Construction materials to suit application.



BILTON PUMP

A general-purpose, close-coupled pump and motor unit. Mounts in any position with no rigid base needed. Especially useful where space is limited. Available with explosion-proof motor. One-third to sixty hp. Capacities to 2000 gpm and heads to 475 ft.

TYPE VMT PUMP

May be designed for pumping liquids from sub-zero to 750° F.—corrosive or non-corrosive—where NPSH is limited. Capacities to 9000 gpm and heads to 575 ft. Smaller standardized (VLT) models also available in capacities to 240 gpm.

SUBMERSIBLE PUMPS

For well pumping, booster stations, or for standby service. Pump and sealed motor operate completely submerged. No pump house or surface structure needed. No well too deep. Ideal where flood menace exists. Capacities to 20,000 gpm and heads to 1800 ft. Write for Bulletins 55-2-700 and 55-3-700.

HYDROPRESS PUMPS

For medium to high pressure pumping at low capacity. Vertical construction saves space, simplifies installation. No relief valves required. Uniform nonpulsating flow. Capacities to 600 gpm. Heads to 10,000 ft.

LIQUID OXYGEN PUMP

Handles liquid oxygen or nitrogen at temperatures as low as −300°F. Insulated section between pump and stuffingbox keeps leakage to a minimum. Standard capacities to 1500 gpm. Heads to 4000 ft. Greater requirements possible by special design.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Gewerkschaft Grieff Bergbau	Dollbergen	500	S	—
Johann Haltermann	Hamburg-Wilhelmsburg [2]	2,000		—
Kraftstoff-Handelggesellschaft GmbH.	Essen	1,700	S	—
Mineraloel- und Asphaltwerke AG. (MAWAG)	Ostermoor on Kiel Canal	3,000	SA	—
Mineraloelwerke Albert Sengewald	Dedenhausen (Hanover) [8]	900	S	—
Mineraloelwerke Peine (Schindler)	Peine (Hanover)	400	S	—
Mobil Oil AG.	Bremen-Oslebshausen [9]	16,000	Comp.	7,700C
Oelwerke Julius Schindler GmbH.	Hamburg-Neuhof	4,000	SLA	—
Ruhrbau Mineraloelraffinerie GmbH.	Muelheim on Ruhr [8]	6,500	S	—
Ruhrchemie AG.	Oberhaussen-Holten [10]	7,500	SC	3,500TC
Ruhroel GmbH.	Bottrop [11]	2,600	S	—
Scholven-Chemie AG.	Gelsenkirchen-Buer [12]	21,500	SCH	5,100C
Union Rheinische Braunkohlen Kraftstoff AG.	Wesseling nr. Cologne [13]	42,000	SCH	11,700T
Wintershall AG.	Salzbergen in Emsland	2,300	SL	—
Zeller & Gmelin	Eislingen in Wurtemberg [8]	170	S	—

[1] 5,300 b/d Platforming capacity.
[2] Half finished charging capacity.
[3] 2,100 b/d catalytic reforming capacity. A 5,600 b/d gas oil desulfurizer was taken into operation in the beginning of 1957.
[4] 6,500 b/d catalytic reforming capacity. (Esso is building 68,500 b/d refinery at Cologne to include 5,360 b/d steam cracker and 8,100 b/d cyclic powerformer.)
[5] 6,400 b/d catalytic reforming capacity.
[6] 2,500 b/d catalytic reforming capacity.
[7] 3,500 b/d catalytic reforming capacity, crude capacity to be increased to 21,000 b/d.
[8] Plant temporarily closed down.
[9] 3,400 b/d catalytic reforming capacity.
[10] 1,800 b/d catalytic reforming capacity.
[11] 800 b/d thermal reforming capacity.
[12] 2,100 b/d catalytic reforming capacity.
[13] 5,600 b/d catalytic reforming capacity and 4,700 b/d thermal reforming capacity.
[14] Platforming unit planned.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Greece:				
Greek Government	Aspropyrgos [1]	27,000	S	—

[1] Under construction: complete July 1957. Plant includes 7,420 b/d Catformer.

Hawaiian Islands:				
Pacific Refineries Ltd.	Honolulu, Oahu [1]	3,000	SA	—

[1] Operates on reduced crude butane.

Hungary:
It is estimated that there are 4 refineries in operation in Hungary with a daily capacity of 24,000 barrels. The first big thermal cracking plant being built at Szoeny refinery; complete 1958.

India:				
Assam Oil Co.	Digboi	8,400	Comp.	1,900T
Burmah Shell Refineries	Bombay [1]	50,000	SCA	12,000C
Standard Vacuum Co. of India	Bombay [2]	30,000	Comp.	5,100C
Caltex Oil Refining (India) Ltd.	Vishaktman	13,500	S	—

[1] 6,700 b/d catalytic reformer, 7,300 b/d Edeleanu plant under construction; complete 3rd quarter 1957.
[2] 4,200 b/d thermal reforming capacity.

Indonesia:				
N. V. de Bataafsche Petroleum Mij (Shell)	Balik Papan, N.E. Borneo	59,000	SW	—
	P. Brandon, Sumatra [1]			
	Paladju, Sumatra [2]	95,000	SC	10,000T
	Tjepu, Java	4,600	S	—
	Wonokroma, Java	3,200	SA	—
N. V. Standard-Vacuum Petroleum Mij.	Sungi, Gerong [3]	71,500	SCW	34,500T

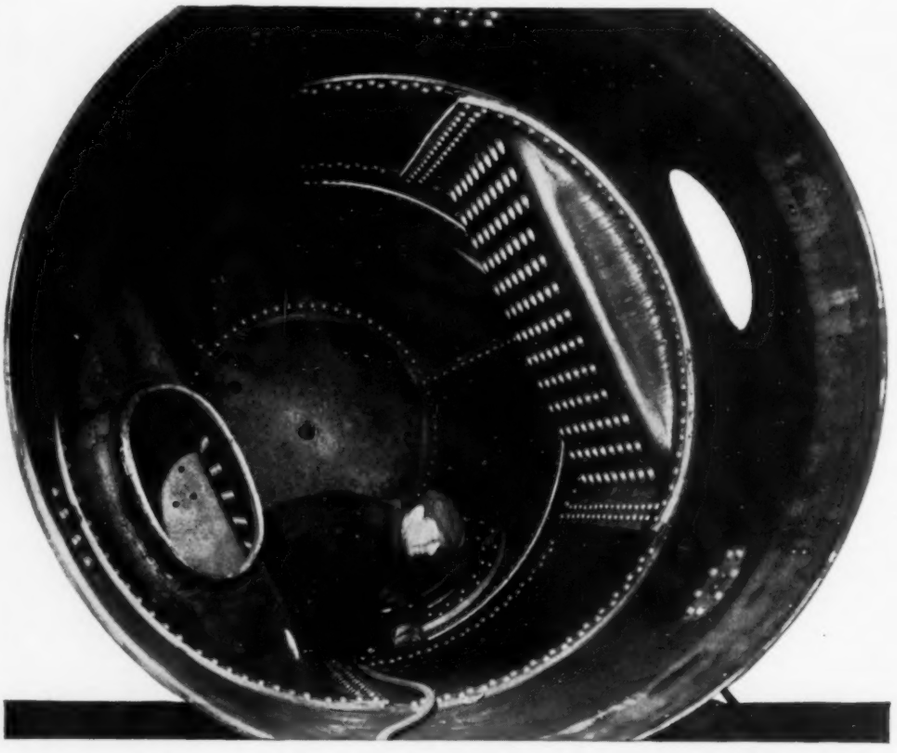
[1] Closed down, impossible to resume operations.

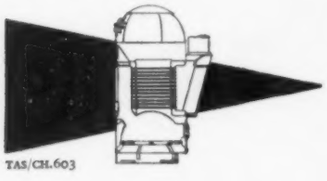
C O C H R A N B O I L E R C O N S T R U C T I O N · N o . 6

A series of descriptions to demonstrate Cochran Craftsmanship.

Fullering & Caulking

When the boiler Shell has been riveted, it is laid on its side on rolls: all plate corners are rounded off, thus allowing internal seams to be caulked continuously with a pneumatic hammer. No caulking is permitted on the external seams which are fullered with a broad tool. All rivet heads are examined carefully at this stage, and later, during the hydraulic inspection, test Caulkers examine every seam and rivet head to ensure that there are no leaks however slight. The above illustration shows a pneumatic Caulker working on an internal seam.



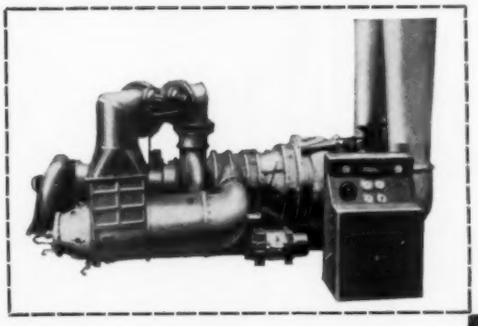


TAS/CH.603

C O C H R A N

COCHRAN & CO., ANNAN, LIMITED, Annan, Dumfriesshire, Scotland and at 34, Victoria Street, London, S.W.1

THIS IS NO PLACE FOR POWER FAILURE!



For details of these versatile, long-life power units write for Brochure No. 9414X.

CONTINUOUS-PROCESSING demands power independence... and there's no independent power unit to match a Ruston Gas Turbine for ensuring complete power security. The extremely simple construction of the Ruston Gas Turbine reduces wear and maintenance to an absolute minimum—it is essentially a long-life, continuous-service power unit.

Ruston Gas Turbines are operating throughout the world, and one installation alone has topped 14,000 hours' service under normal refinery conditions.

Easy to install, space saving, requiring no water and having 'Ruston dependability', these units are unequalled for electric power generation, crude oil pumping, compressor drive *plus the supply of process heat or steam where required.*

RUSTON GAS TURBINES

1300 B.H.P. (Ambient Air Temperature 60°F—at sea level)

RUSTON & HORNSBY LIMITED · LINCOLN · ENGLAND *Associated with Davey, Paxman & Co. Ltd., Colchester*

Built under licence for sale in the U.S.A. by Clark Bros. Co., Olean, N.Y., U.S.A.

Agents in the U.S.A. for oil field services: Beckley, Haltom & Hickman, 1270-6th Avenue, New York 20, N.Y., U.S.A.

(2) 15,000 b/d thermal reforming capacity.
(3) Revamping existing plant, polymerization plant and fluid catalytic cracker.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Iran:				
Iranian Oil Refining Co.	Abadan (1)	460,000	Comp.	102,000TC
National Iran Oil Co.	Kerminshah	3,000	S	—
(1) 75,000 b/d thermal reforming capacity, 27,000 b/d catalytic cracking capacity.				
Iraq:				
Kanaquin Oil Co. Ltd.	Alwand	11,000	S	—
	Basrah	3,430	S	—
Government Oil Refineries	Baghdad (1)	30,000	Comp.	18,000T
	Qaiyarah	1,200	A	—
(1) Thermal reforming capacity 8,000 b/d; cat. cracker planned; capacity of plant to be increased to 50,000 b/d and 5,000 b/d cat reformer to be installed.				
Israel:				
Consolidated Refineries Ltd.	Haifa, Israel (1)	87,000	SA	23,500T
(1) 20,000 b/d thermal reforming capacity.				
Italy:				
Anonima Petroli Italiana	Falconara (1)	26,000	S	8,000T
A.B.C.D.	Ragusa, Sicily	100	A	—
AGIP-Mineraria	Cortemaggiore	2,800	SC	2,800C
Aquila	Trieste	26,000	SC	6,300C
Bianchi Petroli	Cologno Monzese	1,500	S	—
Condor	Rho (2)	45,000	SC	15,000C
Delle Piane	Genoa	1,000	S	—
D.I.C.A.	Carrara	3,000	S	—
Garrone	Genoa (3)	25,800	S	—
I.R.O.M.	Marghera, Venice (4)	35,000	Comp.	—
IPLOM	Genoa	1,000	S	—
I.C.I.P.	Mantua (13)	12,000	SC	2,340C
I.L.S.E.A.	Valmadrera, Como (5)	2,700	S	—
I.R.C.O.	Trieste	500	SA	—
Italia	Cremona	4,500	S	—
INPET—Shell	La Spezia (6)	30,000	SLA	—
NILO	Milan (7)	7,500	S	—
Lombarda Petroli	Villasanta, Milan	5,500	S	—
Purfina Italiana	Genoa (8)	11,000	Comp.	1,500C
	Milan (9)	7,000	Comp.	—
	Rome (10)	11,000	Comp.	1,500C
Petroli d'Italia	Fiorenzuola d'Arda Parma	4,000	SC	1,000T
RASIOM	Augusta, Sicily (11)	55,000	S	—
Raffineria Oli Lubrificanti (ROL)	Viguzzolo, Alessandria	1,400	SL	—
Socony-Mobil	Naples (17)	72,000	Comp.	22,000C
Sanquirico	Genoa	3,000	S	—
SAROM	Ravenna (12)	30,000	S	5,000T
SARPOM	Trecate, Novara (13)	13,300	SC	2,880C
SARN	Novara	1,500	SLA	—
S.P.I.	Fornovo Taro, Parma	2,200	S	—
STANIC	Bari (14)	45,000	S	—
	Leghorn (15)	45,000	SLA	—
Standard-Esso	Trieste	6,100	S	—
STOI	Florence (16)	11,000	S	—
Volpato	Milan	2,100	S	—

(1) 3,000 b/d thermal reforming capacity, cat. reformer under construction.
(2) 5,500 b/d Platforming capacity, hydrodesufurization 6,000 b/cd.
(3) 5,000 b/d cat. reforming capacity, 1,800 b/d thermal reforming.
(4) 6,600 b/d thermal reforming capacity, 2,000 b/d Platforming capacity and 1,650 b/d cat poly. capacity.
(5) 500 b/d cat. reforming capacity.
(6) 3,000 b/d thermal reforming capacity. 6,700 b/d cat. reforming capacity.
(7) 1,100 b/d reforming capacity; Platformer and desulfurization units planned.
(8) 1,500 b/d cat. reforming capacity.
(9) 500 d/b thermal reforming capacity.
(10) 500 b/d thermal reforming capacity.
(11) 5,000 b/d cat. reforming capacity.
(12) 2,000 thermal reforming capacity. 4,000 b/d cat. reforming capacity, gas oil desulfurizer and sulfur recovery units under construction.
(13) 3,150 b/d thermal reforming capacity.
(14) 3,500 b/d thermal reforming capacity.
(15) 3,600 b/d thermal reforming capacity.
(16) Refinery being completely renovated, thermal reforming capacity 1,000 b/d.
(17) Catalytic reforming 10,000 b/sd and hydrodesulfurization 11,000 b/sd units under construction; completion 1958.
(18) Revamping visbreaker to 8,000 b/d topping plant. Catalytic reforming 2,340 b/sd.
Note: Golfo Industria Petrolifera S.p.A. is building a 15,000 b/d refinery at Gaeta, Naples.

Japan:				
Daikyo Oil Co.	Yokkaichi (1)	25,000	Comp.	3,500C
Koa Oil Co.	Marifu (2)	35,000	Comp.	3,000T
Maruzen Oil Co.	Shimotsu (15)	38,000	Comp.	3,000C
	Matsuyama (3)	10,000	S	—

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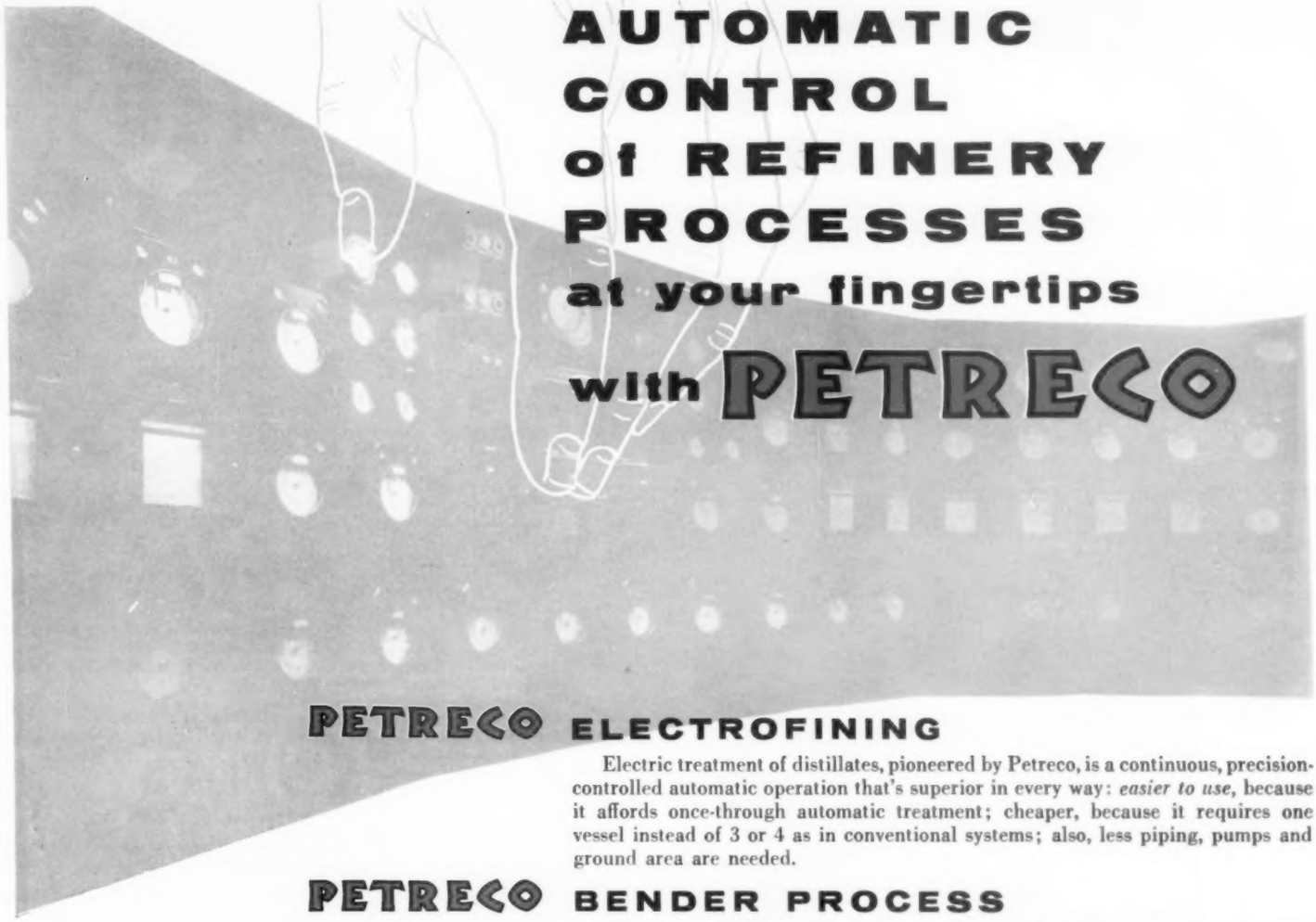

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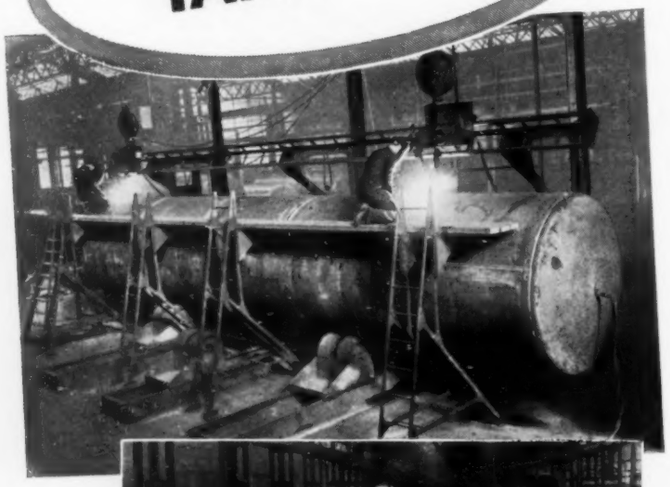

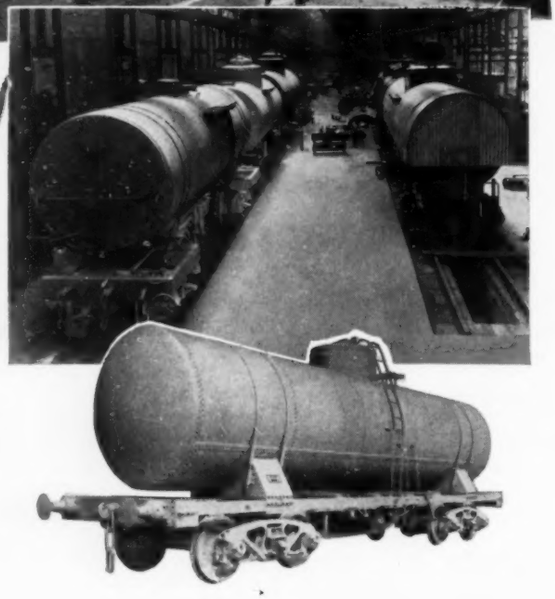

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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Mitsubishi Oil Co.	Kawasaki [4]	29,400	Comp.	3,000T
Nippon Mining Co.	Funakawa [14]	15,300	Comp.	—
Nippon Oil Co.	Akita	6,300	Comp.	—
	Niigata [5]	7,500	Comp.	—
	Kashiwazaki	1,500	SL	—
Nippon Petroleum Refining Co.	Yokohama [6]	46,000	Comp.	5,600C
	Kudamatsu [7]	26,500	Comp.	—
	Muroran	8,300	S	—
Showa Oil Co.	Kawasaki [8]	27,000	Comp.	—
	Yokkaichi [9]			
	Niigata	11,000	Comp.	—
	Hirasawa	3,000	Comp.	—
Toa Nenryo Kogyo K.K.	Shimizu [10]	7,500	SL	—
	Wakayama [11]	48,000	Comp.	13,700TC
Asia Oil Co.	Yokohama [12]	11,000	SLA	—
Idemitzu Kosan K.K.	Tokuyama [13]	35,000	Comp.	—
Toa Oil Co.	Kawasaki	6,000	S	—
Taiyo Oil Co.	Kameoka	1,000	SLA	—
Kita Nippon Oil Co.	Hakodate	12,000	S	—

[1] 2,700 b/sd Platformer construction starts in 1957.
[2] 1,300 b/sd Platformer capacity. 1800 b/sd Platformer and 3,220 b/d feed preparation unit under construction; complete end of 1957.
[3] 3,000 b/sd Platformer under construction; complete mid-year of 1957.
[4] 25,000 b/sd under construction: complete mid-year of 1957 and a 3,000 b/sd Platformer under construction; complete end of 1957. 1,500 b/sd Platforming capacity.
[5] 1,600 b/sd catalytic reformer under construction: complete 1957.
[6] 3,000 b/sd Platformer under construction: complete end of 1957.
[7] 1,300 b/sd catalytic reforming capacity.
[8] 1,500 b/sd catalytic reforming capacity.
[9] 40,000 b/sd topping plant under construction: complete mid-year 1958, also a 9,000 b/sd fluid cat. cracker: complete end of 1958.
[10] 27,000 b/sd topping plant under construction: complete April 1958 also a 3,500 b/sd cat. reformer: complete April 1958.
[11] 4,700 b/sd catalytic reforming capacity.
[12] 1,000 Platformer under construction: complete end of 1957.
[13] 3,000 b/sd Platforming capacity. 7,000 b/sd fluid cat. cracker under construction: complete June 1957.
[14] 1,000 b/d Platformer planned.
[15] 6,000 b/d vacuum flashing plant planned.

Kuwait:

Kuwait Oil Co. Ltd.	Mina al Ahmadi, Persian Gulf [1]	30,000	S	—

[1] Under construction: Crude capacity to be increased by erection of two 80,000 b/d crude units, complete early 1958.

Lebanon:

Iraq Petroleum Co. Ltd.	Tripoli	11,500	S	—
Mediterranean Refining Co.	Sidon	9,000	S	—

Mexico:

Petroleos Mexicanos	Arbol Grande, Tampico	40,000	SAL	—
	Atzacapoltzalco, D.F. [1]	100,000	SCA	14,500T
	Ciudad Madero, Tampico [2]	85,000	SCA	6,000T
	Mata Redonda, Vera Cruz [6]	12,000	SC	6,000T
	Minatitlan, Vera Cruz [3]	50,000	SC	15,000C
	Poza Rica, Vera Cruz [7]	6,000	S	—
	Reynosa, Tampico [4]	7,000	S	—
	Salamanca, Gto [5]	40,000	Comp.	5,000T

[1] 30,000 b/d vacuum unit, 20,000 b/d cat. cracker, 3,000 b/d alkylation unit and 800 b/d cat poly unit planned for construction.
[2] 12,000 b/d cat. reforming capacity. Crude capacity to be increased to 102,000 b/d, a cat. cracker, alkylation, polymerization and coking units under construction.
[3] Lube plant under construction; complete November 1957.
[4] 10,000 b/d additional distillation capacity and a 2,200 b/d thermal cracking unit planned for construction.
[5] 15,000 b/d cat. cracker and grease plant planned.
[6] Crude capacity increase of 20,000 b/d planned.
[7] In connection with 90,000 b/d crude stabilizer.

Netherlands:

N.V. de Bataafsche Petroleum Mij (Shell)	Pernis [1]	330,000	Comp.	86,000TC
Caltex Petroleum Mij. N. V.	Pernis [2]	41,000	SC	9,000T

[1] 10,000 b/d thermal reforming capacity, 20,000 b/d thermal cracking capacity and 66,000 b/d cat. cracking capacity. Cat. reformer 12,700 b/d; two hydrodesulfurizers, 16,400 b/d and 7,800 b/d under construction complete 2nd quarter 1958. Alkylation plant 2,800 b/d projected for completion 1st quarter 1958.
[2] 6,000 b/d thermal reforming capacity. A Platformer and Unifiner under construction; complete 1957.

Netherlands West Indies:

N.V. Curacaosche Petroleum Industrie Mij.	Curacao [1]	210,000	Comp.	120,000T
Lago Oil & Transport Co.	Aruba [2]	440,000	Comp.	340,000TC

[1] 16,000 thermal reforming capacity. A 38,000 b/d cat. cracker and 30,000 b/d feed plant under construction: complete 4th quarter 1957.

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(2) Includes 16,000 b/d thermal reforming capacity and 43,000 b/d cat cracking capacity.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Norway:				
A/S Norske Esso (A/S Ostlandske Petroleum-Compagni)	Valloy per Tonsberg	1,800	SLA	—
Pakistan:				
Attock Oil Co.	Punjab, Rawahlpindi	5,000	S	—

Panama:
Two refineries planned for construction. A 55,000 b/d refinery by Panama Refining and Reconstruction Co. and a 50,000 b/d by Refineria Panama S.A.

Peru:				
Cia. de Petroleo Ganso Azul	Agua Caliente	1,000	S	—
Empresa Petrolera Fiscal	Iquites	1,500	S	—
International Petroleum Co.	Talara	43,500	Comp.	14,500T
Philippine Islands:				
Caltex (Philippines) Inc.	Batangas	13,000	SC	5,400C

Note: Shell (Philippines) is negotiating for the building of a refinery at Manila.

Poland:
It is estimated that there are 7 refineries in operation in Poland with a crude capacity of 12,000 b/d.

Portugal:				
"Sacor" S.A. Concessionaria de Refinacao de Petroles em Portugal	Cabo Ruivo	27,000	SLA	10,000C
Puerto Rico:				
Caribbean Ref. Co.	San Juan	10,500	SC	5,000C
Commonwealth Oil Ref. Co.	Quayanella Bay (1)	55,000	SC	53,000C

(1) 3,730 b/d cat. reformer, 1,540 cat poly unit, 41,000 b/d distillate treating unit, 53,000 b/d cat. cracker.

Romania:
It is estimated that 15 Romanian refineries have a crude capacity of 157,000 b/d and a cracking capacity of 69,000 b/d.

Saudi Arabia:				
Arabian American Oil Co.	Ras Tanura (1)	189,000	Comp.	—

(1) 25,500 b/d thermal reforming capacity, 13,700 b/d Hydroformer capacity. Under construction 15,000 b/d desulfurization unit; complete Aug. 1, 1957.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
South Africa:				
So. Africa Torbanite Mining & Refining Co.	Boksburg N. Transvaal	2,000	SAC	2,000T
Standard Vacuum Refining Co. of So. Africa Pty. Ltd.	Durban (1)	18,000	Comp.	5,700C
Spain:				
"Campsa" Coa. Arrandetaria del Monopolio de Petroleo S.A.	Barcelona	700	S	—
"Cepsa" Cia Espanola de Petroleo S.A.	Canary Islands (1)	35,000	Comp.	3,500T
Refineria de Petroles de Escombreras, S.A.	Escombreras (2)	80,000	SL	—

(1) 5,000 b/sd Platforming capacity. 35,000 b/sd topping distillation unit under construction.
(2) 9,000 b/d thermal reforming capacity and 11,000 b/d Platformer.

Sweden:				
A-B Nymas Petroleum	Nynasham (1)	14,000	Comp.	1,000T
	Malmo	1,900	SA	—
Koppartrans Oljeaktiebolag	Goteborg (2)	30,000	S	—
Svenska Skifferoje A/B	Narkes-Kvarntorp (3)	2,000	S	—

(1) 1,900 b/d thermal reforming capacity.
(2) 4,500 bd thermal reforming capacity and 5,500 catalytic reforming capacity.
(3) Under construction: Ammonia plant, Hydrofiner and Hydroformer for gasolines.
Note: A-B Nymas Petroleum plans to build a 3,000 b/d refinery at Golhenburg.

Switzerland:				
A.G.	Rotkreuz (1)	1,500	S	—
Schweiz-Sprengstoffabrick	Dottikon (2)	350	S	—

(1) Operates on tops.
(2) Manufactures special naphthas.

Trinidad:				
The Texas Co.	Brighton	5,000	S	—
Trinidad Oil Co. Ltd.	Point-a-Pierre (1)	85,000	SCA	48,500TC
Shell Trinidad Ltd.	Point Fortin	37,000	Comp.	—

(1) 36,000 b/d thermal cracking capacity and 22,500 b/d cat. cracking capacity. 8,000 b/d Platformer and 10,000 b/d hydrotreater under construction.

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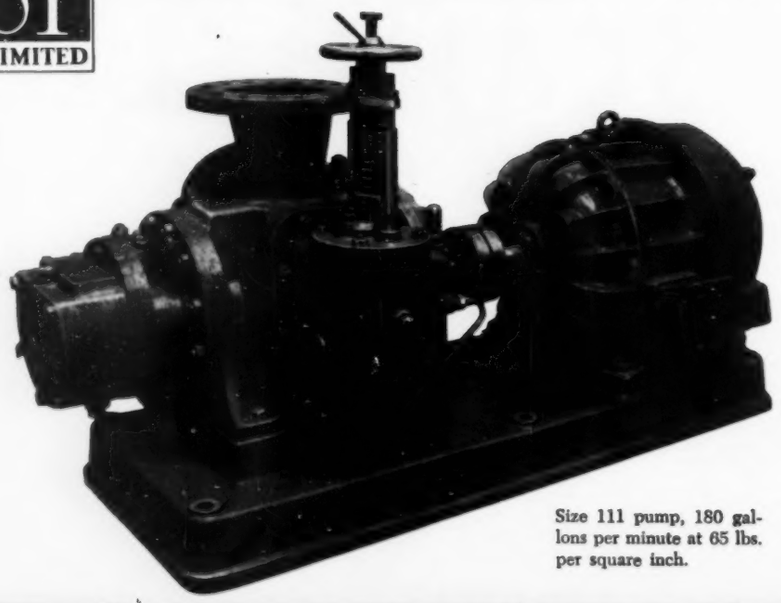

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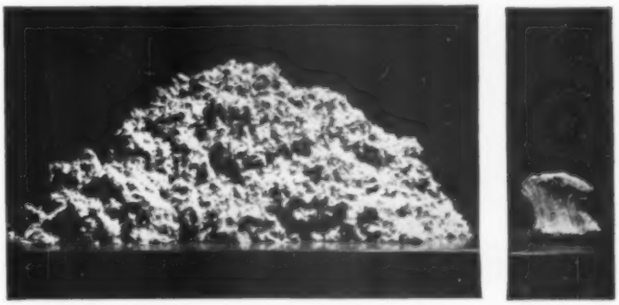

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EFFICIENCY DATA SHEET—PIPE SIZES 6" to 10" BORE.

HOT FACE TEMPERATURE °F.			400°F			600°F			800°F		
THERMAL CONDUCTIVITY K = B.Th.U. in. sq. ft. hr. in. °F.			0.43			0.47			0.53		
MEAN TEMPERATURE °F.			250			350			450		
Nominal Pipe Size	O.D. pipe	Thickness of Insulation	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.
6"	61"	1"	135	87·7	126	233	90·6	167	354	92·5	218
		1½"	102	90·8	107	177	92·9	135	270	94·3	171
		2"	83·6	92·4	97	145	94·1	118	223	95·3	145
		2½"	71·8	93·5	91	125	95·0	107	192	96·0	128
		3"	63·5	94·2	86	110	95·5	100	170	96·4	117
		3½"	57·3	94·8	83	100	96·0	95	154	96·7	109
		4"	52·6	95·2	81	91·7	96·3	91	142	97·0	103
8"	81"	1"	130	88·0	127	225	90·8	169	341	92·7	222
		1½"	97·7	91·0	108	169	93·1	137	258	94·5	174
		2"	79·2	92·7	98	138	94·4	120	211	95·5	148
		2½"	67·4	93·8	92	117	95·2	109	180	96·1	131
		3"	59·2	94·6	87	103	95·8	102	159	96·6	120
		3½"	53·2	95·1	84	92·7	96·2	96	143	96·9	111
		4"	48·5	95·6	82	84·6	96·5	92	131	97·2	105

These figures are compiled from results of official tests by THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON, computed in accordance with formulae shown in BRITISH STANDARD SPECIFICATION appendices.

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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Turkey:				
Turkiye Petrolleri Anonim Ortakligi	Batman	7,000	SCA	3,000C

Note: A-B Nymas Petroleum plans to build a 3,000 b/d refinery at Gothenburg.
Note:The government has authorized the construction of a 15,000 b/d refinery at Izmit near Istanbul; completion August 1958.

United Kingdom:				
BP Refinery (Kent) Ltd.	Isle of Grain, Kent [1]	90,000	SCL	12,500C
BP Refinery (Grangemouth) Ltd.	Grangemouth [10]	49,000	SC	12,500C
BP Refinery (Llandarchy) Ltd.	Llandarchy S. Wales	70,000	Comp.	12,500C
Berry Wiggins & Co. Ltd.	Kingsmouth on the Medway nr Rochester, Kent	4,300	S	—
	Weaste [2]	1,850	S	—
Briggs & Co. Ltd., Wm.	Dundee, Scotland	1,000	SLA	—
Carless Capel & Leonard	London	300	S	—
Esso Petroleum Co. Ltd.	Fawley [3]	162,000	Comp.	44,000C
Lobitos Oil Fields Ltd.	Ellesmere Port [4]	4,000	Comp.	1,000T
London & Thameshave Oil Wharves Ltd.	Thameshaven	2,000	LA	—
Manchester Oil Refinery Ltd.	Trafford Park [5]	3,000	Comp.	—
Scottish Oils Ltd.	Pumpherston, Scot.	3,500	SC	2,800T
Shell Refining & Marketing Co. Ltd.	Stanlow, Ellesmore Port [6]	100,000	Comp.	33,000C
	Shell Haven, Essex [7]	75,000	Comp.	—
	Heysham, Lancs. [8]	36,000	S	—
Starhaven Refineries Ltd.	Ardrossan, Scot.	3,200	S	—
Vacuum Oil Co. Ltd.	Coryton, Essex [9]	35,000	Comp.	9,000C

[1] 6,000 b/d Platforming capacity. To increase crude capacity to 180,000 b/d, a 90,000 b/d distillation unit, 10,000 b/d cat. reformer, 12,000 b/d thermal reformer, two 10,000 b/d Hydrofiners, 12,000 b/d crude stabilizers, three 8,000 b/d solutizers, two 8,000 b/d copper chloride units and a 2,250 alkylation unit, 45 t/d sulfur recovery unit; complete mid, 1958.
[2] A 1,620 b/d two stage distillation unit under construction.
[3] 10,000 b/d Hydroforming capacity. Hydrofiner under construction complete mid-1957, a 70,000 b/d atmospheric distillation unit under construction complete end 1957. Steam cracker and butene dehydrogenation unit, complete mid-1958.
[4] A 800 b/d Platformer.
[5] A d-picoline plant under construction; complete late 1956.
[6] 10,000 b/d thermal reforming capacity and 9,000 b/d Platforming capacity.
[7] 10,000 b/d thermal reforming capacity, 6,700 b/d Platforming capacity, 80,000 b/d crude unit building, complete 3rd quarter 1958.
[8] 4,000 b/d thermal reforming capacity.
[9] 6,000 b/d catalytic reforming capacity. A 6,000 b/d Sovaformer.
[10] Existing crude unit to be replaced by new 62,000 b/d still, completion 1959.

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Uruguay:				
Administration Nacional de Combustibles, Alcohol y Portland (ANCAP)	Montevideo [1]	28,000	SCA	7,000TC

[1] 5,000 b/d catalytic cracking capacity and 3,000 thermal cracking capacity. Under construction: 28,000 b/d crude capacity increase, catalytic cracker and asphalt capacity increased 750 b/d; complete 1957.

U.S.S.R.
The estimate of the number of refineries in Russia is 68. Estimated daily crude capacity is 1,800,000 b/d and the cracking capacity is 520,000 b/d.

Venezuela:				
Creole Petroleum Corp.	Amuay Bay [1]	250,000	S	—
	Caripito	60,000	SC	35,000T
Phillips Oil Co.	San Roque [2]	3,000	WAX	—
Richmond Exploration Co.	Bajo Grande [3]	10,000	SA	—
Shell: Colon Development Co. Ltd.	Casigua	1,000	S	—
	La Rivera	300	S	—
	El Calvario	300	S	—
Compania Shell de Venezuela Lts.	San Lorenzo	45,000	S	—
	Cardon [4]	203,000	SCL	25,000T
Sinclair Oil & Refining Co.	Puerto La Cruz	35,000	S	—
Texas Petroleum Co.	Tucupita	10,000	S	—
Venezuela Gulf Refining Co.	Puerto La Cruz [5]	59,000	Comp.	23,000T

[1] 11,000 b/d Hydroforming capacity; 104,000 b/d crude unit, complete Oct. 1957; 650 b/d lube plant; 17,000 b/d Hydrofiner planned.
[2] 3,500 b/d crude unit planned.
[3] 20,000 b/d crude unit planned.
[4] 8,500 b/sd thermal reforming capacity. A 35,000 b/d cat. cracker under construction and a 2,300 b/d alkylation unit projected; complete 3rd quarter 1957. Also projected is an 80,000 b/d distillation unit; complete 4th quarter 1958.
[5] 11,000 b/sd thermal reforming capacity. An 8,660 b/d fluid cat. cracker to be complete 1st quarter 1958; 14,000 b/d visbreaking capacity.

Yugoslavia:				
Government:	Rijeka	7,000	Comp.	600T
	Sisak	10,000	S	—
	Bosanski Brod	2,800	SIC	500T

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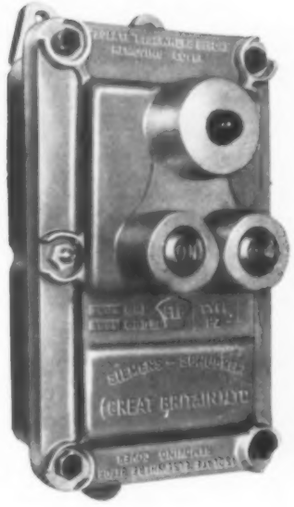

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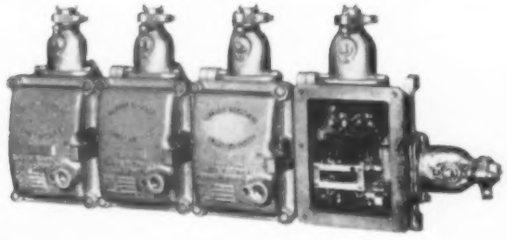

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Canadian Pipe To Supply USA Firms

Marking the first major purchase of Canadian pipe by USA firms, a $4 million contract has been signed by two affiliated western Canadian companies to supply 561 miles of pipe to Northern Natural Gas Co., Omaha. Under terms of the contract, Canadian Western Pipe Mills at Port Moody, B.C., will supply 350 miles of pipe in 2-in., 3-in., and 4-in. sizes, valued roughly at $1,850,000. Alberta Phoenix Pipe Mill, Edmonton, Alt., will supply the balance—211 miles of 6-in. pipe. This pipe will be used for construction of feeder systems in the markets served by Northen Natural in South Dakota, Minnesota, and Iowa.

Price Investigation Defeated

The Alberta legislature defeated a resolution calling for a royal commission investigation of the recent 18-cent crude price increase in Alberta to determine whether it was justified.

Hess Appointed To Geophysical Associates

Geophysical Associates of Canada Ltd. has announced the appointment of Gordon Hess to the position of executive vice president. Mr. Hess has been with the firm since 1950, as chief supervisor of Canadian operations. Born in Calgary, he is a graduate of the University of Alberta, and holds a degree in Geology. Succeeding Mr. Hess as chief supervisor is J. H. B. Campbell, who comes from Melbourne, Australia. Mr. Campbell has been with the firm since 1951. A. A. M. VanDijk was appointed supervisor. He is from The Hague, Netherlands, and has been with the firm since 1952.

Electro-Tech In New Plant

Electro-Technical Labs., division of Mandrel Industries Inc., has moved to its new plant at 5134 Glenmount Drive, P.O. Box 13243, Houston, Texas. The new, half-million dollar plant will greatly increase production capacity for geophysical equipment.

GEORGE T. NAFF, vice chairman of the board of Texas Eastern Transmission Corp., has retired. Mr. Naff, who has been with the company virtually since it was founded in 1947 and served as president for almost three years, will serve as a consultant to Texas Eastern and others on oil and gas matters, and will engage in the private practice of law.

K. W. BRILL has been promoted to assistant to E. F. Battson, vice president and chairman of the executive committee of Continental Oil Co., with headquarters in New York.

WILLIAM E. HUMPHREY, geologist, has left DeGolyer and MacNaughton of Dallas, Texas, after six years as representative in Mexico and Spain. Dr. Humphrey is now associated with TULM Corp. at 2204 Commerce Building, Houston, Texas.

M. N. BROUGHTON has been appointed staff geologist in the New York office of The Texas Co.'s foreign operations department (Western Hemisphere and West Africa). Mr. Broughton has been staff geologist of Texaco's domestic producing department since 1954.

Cuban Tax Exemption For Public Works

A cuban government resolution reimburses The Texas Co. (West Indies) Ltd. for certain public-works construction by an exemption of 60% of the gasoline tax of 10 cents a gallon. The tax is due on gasoline refined from imported crude oil.

Argentina's Alzogaray Favors Private Oil

Controversy over admitting private oil companies to Argentina to develop the country's oil keeps mounting. Alvaro Alzogaray, former Minister of Commerce and Industry in the Aramburu government, head of the Partido Civico, continues a leading critic of the present monopoly under YPF.

YPF he calls the symbol of Argentina's "incapacity" to advance the best interests of the country. With Argentina using each year 13 million cubic meters of oil, YPF produces only four million, he says. He points to oil progress in Canada, Bolivia, Venezuela, France, and Peru under private industry.

Awards Pipeline Contract

Tecumseh Pipe Line Co. has awarded a contract for the construction of its 20-in. 200-mile crude pipeline between East Chicago, Ind., and Cygnet, Ohio, to O. R. Burden Construction Co., of Tulsa. Tecumseh is owned by Sinclair Pipe Line Co., Asland Oil & Refining Co., and The Pure Oil Co. Sinclair will supervise construction and operate the system.

ASTM To Publish Jet Fuel Data

ASTM Committee D-2 on Petroleum Products announced at the 60th Annual ASTM Meeting, June 17-21, 1957, in Atlantic City that it plans to recommend for publication as information this year the *Proposed Methods of Test for Thermostability Techniques for Jet Fuels*. These methods, which are based on work done by the Co-operative Research Council, are now being compiled, and it is expected they will be available for inclusion in the 1957 edition of the special compilation of ASTM Standards on Petroleum Products and Lubricants.

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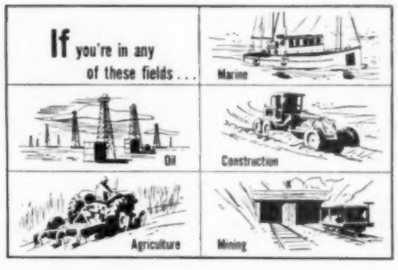

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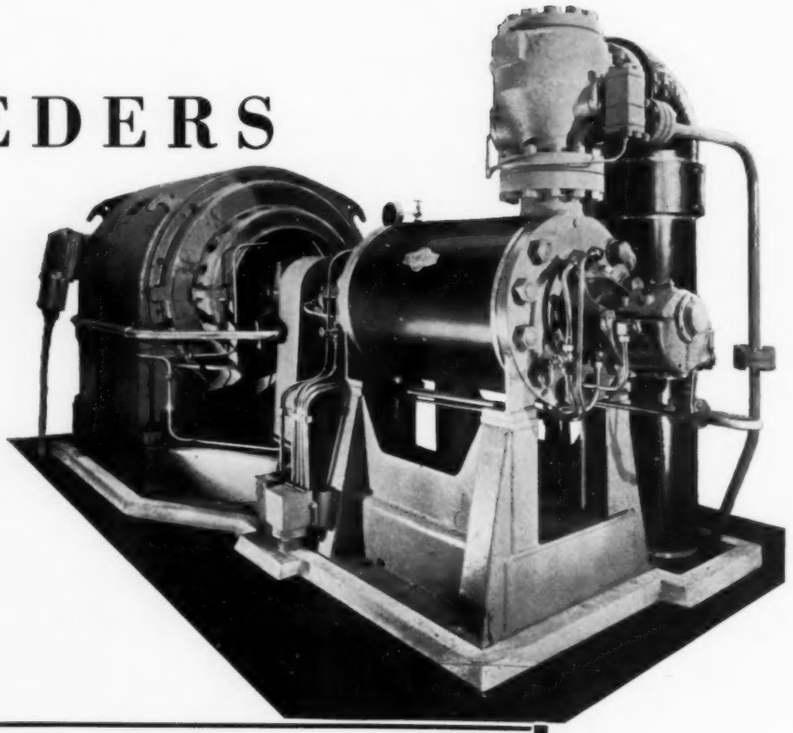

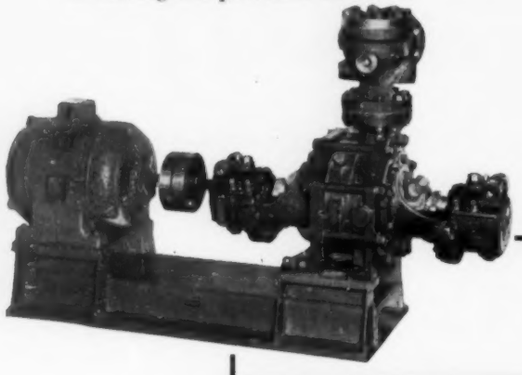

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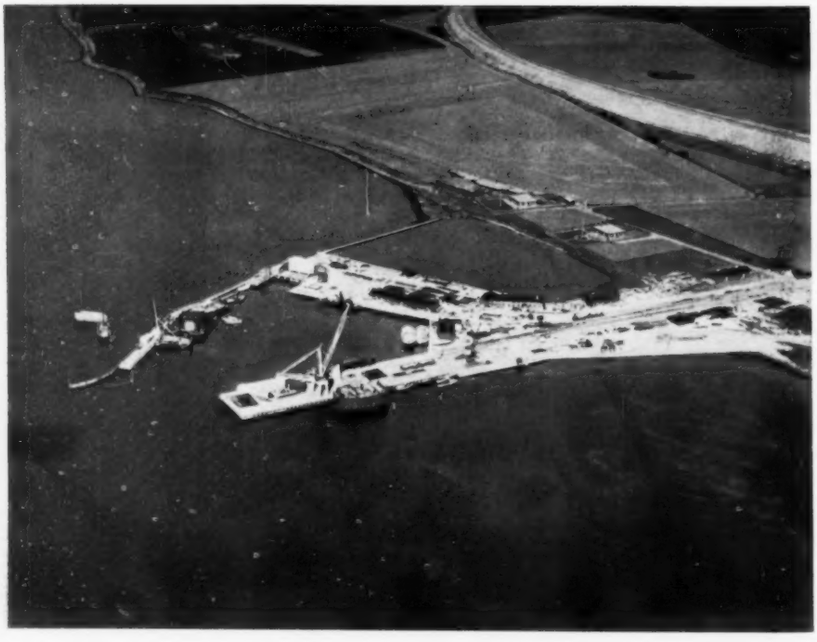

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Kurt W. Fleischer

KURT W. FLEISCHER has been elected vice president, Fluid Processing Division, Selas Corp. of America, Dresher, Pa.—with full responsibility for all activities of the division, including engineering and sales supervision of Selas Constructors Inc., Houston, a subsidiary.

JAMES W. BOZEMAN has been elected executive vice president of TUSCO Corp. formerly Tubular Service & Engineering Co., according to announcement of W. H. Hopkins, president of TUSCO, Houston, Texas. In his new position, Mr. Bozeman will be active in the management of TUSCO's oilfield service companies, its building-material division, and its Navion aircraft division. Other officers, besides Mr. Hopkins and Mr. Bozeman, are E. G. Amundsen, vice president; J. L. McConn, treasurer; and Thad T. Hutcheson, secretary.

STANLEY T. REYNOLDS will succeed J. J. Hanna, retired, as manager of Imperial Oil Co. Ltd.'s Calgary refinery. Mr. Reynolds has been plant superintendent at the company's Edmonton refinery for the past four years. Mr. Hanna had been with the Calgary refinery since 1922.

SAM H. CASEY, former general manager of supply and transportation of American Oil Co., has joined Commonwealth Oil Refining Co. as vice president and a member of the board, with headquarters in New York.

J. B. SANDERS, president of Triangle Refineries Inc., has been elected a senior vice president of Kerr-McGee Oil Industries Inc. He will continue to head the management of Triangle, which operates product terminals and sales offices in 15 states of the Midwest and South. Kerr-McGee recently acquired all the capital stock of Triangle, which will operate separately.

JAMES E. HARRELL, Jr., has joined the staff of Universal Oil Products Co. to represent its Products Department in technical sales work in the Gulf Coast area. He will also assist refiners in treating, blending, and general refinery problems.

James E. Harrell, Jr.

W. C. Young

W. C. (Bill) YOUNG and Harry A. Cecasrini have been appointed sales engineers for Cooper-Bessemer International—devoting their energies to shipments outside this country. The New York-based company services the petroleum, petrochemical, and power-generating industries throughout the world.

Harry A. Cecasrini

GEORGE ORESCAN has been elected treasurer of Universal Oil Products Co., Des Plaines, Ill. George A. Bockman, former treasurer, becomes special assistant to Universal's president. This is a newly-created position.

ELMER R. WEAVER, chief of the Gas Chemistry Section of the National Bureau of Standards, retired as of May 31 after 45 years' service.

H. B. NICHOLS has been elected senior vice president, and G. R. Ferguson a vice president, of California Texas Oil Co. Ltd.

L. F. McCOLLUM, president, Continental Oil Co.; George G. McGhee, McGhee Production Co.; and Emilio G. Collado, treasurer for Standard Oil Co. (N.J.) have been elected to membership on the 150-man Board of Trustees of the Committee for Economic Development.

E. H. COUNTS, superintendent of operations in the gas and gas products department of Sinclair Oil & Gas Co., Tulsa, has been promoted to staff general superintendent of the department. He succeeds the late J. L. Gallagher.

Eugene L. Miller

EUGENE L. MILLER has been elected president and general manager of Cooper-Bessemer Corp., Mt. Vernon, Ohio, according to announcement of chairman L. F. Williams. Mr. Miller has been assistant general manager since 1954.

HAROLD R. KEMMERER, assistant manager of Shell Oil Co.'s manufacturing research department, has been named manager of the company's products application department—succeeding A. B. Culbertson, retired.

CHADWICK H. CARPENTER has been appointed to the newly created post of executive assistant to the president of Standard Oil Co. (New Jersey), New York.

A. F. REED, vice president of Lion Oil Division, has been appointed assistant in sales matters to executives for both Lion Oil Division and Inorganic Chemicals Division of Monsanto Chemical Co., at El Dorado, Ark. J. H. Sheehan, also a vice president of Lion Oil Co. Division, assumes responsibility for petroleum product sales—succeeding Mr. Reed.

QUENTIN W. REGENSTEIN has been appointed assistant manager of Socony Mobil Oil Co.'s 16-state Central Region, at Chicago, Ill.

MARVIN MARCUS has been appointed sales manager, government operations, for The Lummus Co., engineers and constructors for industry.

P. C. THOMAS, vice president in charge of Shell Oil Co.'s midwestern marketing divisions, has moved his office from New York to Chicago. New headquarters are at 624 S. Michigan Ave., where the firm's Chicago division office is also located. Mr. Thomas says the move was made to provide more convenient administration in the area for which he is responsible. This includes all the marketing activities centered in Shell's Cleveland, Detroit, Indianapolis, Minneapolis, St. Louis, and Chicago divisions.

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Esso Computing Center

Esso Research and Engineering Co. has announced plans for a large-scale technical computing center at the firm's facilities in Linden, N. J. Heart of the operation will be an IBM 704 scientific computer, on order now for delivery in December. One of the highest capacity technical computers available, with a "memory" for storing some 165,000 digits at one time, the 704 unit will be one of only two in use throughout the entire oil industry. Edwin J. Newchurch has been named an assistant director of the company's petroleum development division, and will be responsible for setting up and managing the center. He had been employed at the Esso Research Laboratories in Baton Rouge, La.

HARRY R. HAMMERLE, manager of direct sales, foreign marketing department, Gulf Oil Corp., has retired after 43 years of service.

DR. JOHN G. McNAB has been appointed coordinator of petroleum products and medical research at Esso Research and Engineering Co. In his new position, Dr. McNab is responsible for the management of the company's research aimed at developing new or improved oil products such as engine fuels, lubricants, industrial oils, greases, waxes, and chemical additives.

ELLIOTT W. ATKINSON, vice president-treasurer of the Lion Oil Co. Division of Monsanto Chemical Co., has been appointed assistant to the president to handle special projects.

W. A. RUSSELL has retired from Seaboard Oil Co., after over 34 years in positions of responsibility in the accounting and financial departments in Mexico, the Western United States, and Canada.

R. T. WIDNEY has been appointed superintendent of gas operations for Cities Service Oil Co.'s production division.

New Tidewater Refinery Posts

The appointment of eight men to supervisory posts at Tidewater Oil Co.'s new Delaware refinery, now nearing completion 15 miles south of Delaware, has been announced. Appointed were Lyle C. Pratt, Bernard E. Woods, Russell S. Pease, and Louis G. Fuller named shift foremen of the crude-coking-cracking areas; and William F. Limber, Edward F. Naus, Earl J. Borde, and John J. Scott named shift foremen of the alkylation-polymerization-reforming-desulfurizing areas.

Council Approves Refinery Building

Calgary City Council approval of special residential concessions in the Ogden district, where citizens had vigorously protested refinery expansion, has cleared the way for Imperial Oil Ltd. to proceed with its proposed $17 million modernization and enlargement program in the district. Capacity of the refinery will be doubled to about 17,000 b/d.

Broggini New President of Badger

A. J. Broggini has been named president of the Badger Manufacturing Co. He succeeds Mr. George C. Hargrove who is retiring from active service. Mr. Hargrove will, however, remain available for consultation. In addition to his new duties, Mr. Broggini will continue as chairman of the executive committee. He is also a member of the company's board of directors. Besides its home base in Cambridge, Badger Manufacturing also maintains offices in New York and Houston, and has recently joined with Comprimo NV to establish Badger-Comprimo, NV, in The Hague and Badger-Comprimo (Belgium) SA. Mr. Broggini is a director of these subsidiaries.

Dresser Sales Up 37%

The level of sales of Dresser Industries Inc., Dallas, was maintained at near record levels for the quarter ended January 31. Sales amounted to $63,171,427, which compares with $46,150,055 for the same quarter the previous year, or an increase of 37%, as reported in the company's shareholders' letter by Chairman H. N. Mallon and President J. B. O'Connor.

Panama To Have 55,000 B/D Refinery

Panama Refining & Petrochemical Co. Inc., Panama City, republic of Panama, recently signed a contract with Foster Wheeler Corp., New York, for construction of a 55,000 b/d refinery at Colon. Work on the $33 million-plus project will begin in 60 to 90 days, and target date for completion is less than two years.

Panama Refining & Petrochemical, owners and operators of the new refinery, is owned jointly by the partnership of Eugene duPont III, of Wilmington, Del., and John Shaheen of New York. Mr. Shaheen stated in New York recently "we have signed contracts with several major USA oil companies for a 10-year supply of crude, and have also signed contracts for the entire output of the refinery for the next 10 years."

The new installation will be the first of its kind in Panama.

Imperial Oil To Spend $160 Million

Imperial Oil Ltd. forecasts its 1957 expenditures at $160,000,000 for exploration and capital facilities, as compared with $134,000,000 for the preceding year when records were set in all major phases of company operations. Imperial's exploration and capital expenditures since the discovery of the Leduc oil field topped $800,000,000, as of December 31, 1956.

New Burma Refinery

The new Burmah Oil Co., at Syriam, was opened in March by Deputy Prime Minister of Burma U Ba Swe. This refinery, with a capacity of 3,500 b/d, was mainly reconstructed from materials salvaged from the sabotaged Syriam, Sekkyi, and Thilawa refineries. Reconstruction was in the hands of Foster Wheeler Ltd. At the old Syriam refinery, all grades of oil products and wax were made; but the new refinery will only make motor fuels, kerosines, and fuel oil. The paraffin wax will be cracked for motor fuel. The addition of the Syriam refinery to the Chauk refinery renders Burma self-sufficient in refinery capacity.

New Petro-Tech President

The Petro-Tech Service CA has elected John M. Miner president of the company. Petro-Tech is a member of Dresser Industries Inc., and a subsidiary of Dresser Industries AG.

Close Los Angeles Office

The Los Angeles office of Seaboard Oil Co. will be discontinued, June 30. California operations will be handled by the Bakersfield office. N. A. Rousselot will be special representative reporting to the executive vice president on all matters pertaining to the company's joint operations in the Kettleman Hills, the Guijarral Hills, Pleasant Valley, and Coalinga Nose oil fields. He will have an office at 3500 Ocean Boulevard, Corona del Mar, Calif.

Buys Triangle

Triangle Refineries Inc., of Houston, is being acquired by Kerr-McGee Oil Industries Inc., Oklahoma City. It will continue to operate under its same name, as a subsidiary of Kerr-McGee, with the same management and personnel as before. J. B. Saunders, founder of Triangle, will continue as president and chief executive officer. The other officers of Triangle, all of whom will be retained in their present capacities, are: J. Howard Barksdale, executive vice president; Hubert H. Raborn, vice president and secretary; and C. D. Tinsley, vice president.

Donahoe Joins UOP

Edward J. Donahoe, formerly with Chicago Bridge & Iron Co., has joined the public-relations staff of Universal Oil Products Co., and will be responsible for handling the company's advertising. His work will involve the selection of media, preparation of publication advertising, brochures, and special promotions dealing with UOP processes and products.

New Harvester Foreign Directors

Hugh A. Davies and Harris E. Swanberg have been appointed assistant directors of Foreign Operations of International Harvester Co. Under the guidance of Jack L. Camp, director of foreign operations, Mr. Davies will give special attention to the Latin American and Pacific area; and Mr. Swanberg to the European, Middle Eastern, and African areas of the company's business.

Heads Pipe Linings Sales

V. L. Greedy has been appointed sales manager for Pipe Linings Inc., Los Angeles. He has been southern California district sales manager for the American Pipe & Construction Co. His experience with that concern over the past three years fits him especially well for his new responsibility.

New Turkish Refinery

A new 65,000 b/d refinery in Turkey has been announced by Mobil Overseas Oil Co. Inc. The refinery, scheduled to go onstream in 1960, will be built, as requested by the Turkish government, by a group of companies composed of Mobil Overseas Oil Co. Inc., the British Petroleum Co., California Texas Corp., and the Royal Dutch-Shell group. Installations will include a crude petroleum distillation unit and a catalytic reforming unit for upgrading of naphtha.

Japan To Buy Kuwait Oil

Idemitsu Kosan (Industrial), a Japanese firm specializing in oil products, has concluded a long-term contract with Gulf Oil Corp. (USA) for purchase of crude over a 10-year period. Under the contract, Japanese company will buy 15,000 b/d of Kuwait crude, about half the daily refining capacity of its Tokuyama refinery—purchase price to be $1.72 per barrel or less. Transportation of crude from the Persian Gulf to Japan will be in the two large tankers (84,000 tons and 130,000 tons each) of National Bulk Carrier Ltd. (USA).

Oil Show Dates Set

Dates for the next international Petroleum Exposition at Tulsa have been set for May 15 to 24, 1959, to allow visitors from more than 50 foreign countries to attend both the exposition and the Fifth World Petroleum Congress which is scheduled to be held in New York, N.Y., May 30 to June 6, 1959.

Coinciding with the 100th anniversary of the drilling of the Drake well at Titusville, Pa., in 1859, the exposition is expected to be the largest in its history.

Refinery For Jordan

The Dutch Comprimo Co. was to send a group of its experts to Jordan to select a site for a new Jordan oil refinery. Plans and specifications already had been drawn. Because some Middle East pipelines pass through Jordan, that country has the right to purchase a certain amount annually of crude passing through, inasmuch as Jordan has no oil resources of its own. Capital from other Arab countries is sought for the project, which is to cost about $20 million. A similar scheme some seven years ago was not favored by the major companies, and was dropped.

Petrobras To Make Advance Reports

Petrobras is to submit annual reports on its plans for the year ahead in all phases of oil to the National Petroleum Council, under a new decree of the President of Brazil. First report is due September 30. Petrobas also is required to file certain progress reports to the NPC under the decree which is regarded as giving more authority to NPC.

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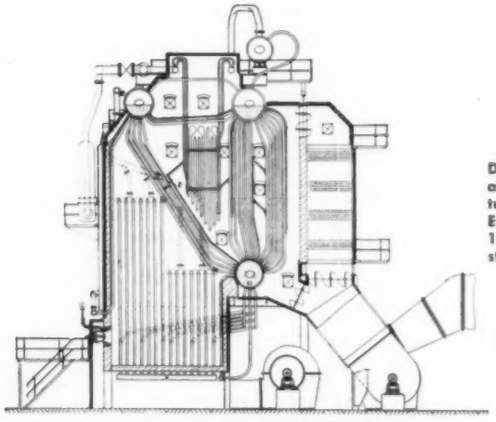

Diagram shews an oil fired water tube boiler. Evaporation 175,000 lb. of steam per hour.

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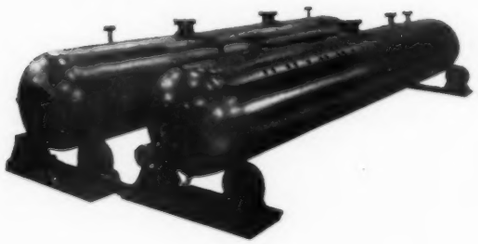

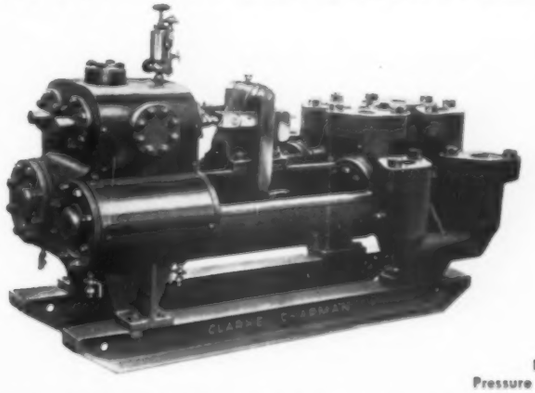

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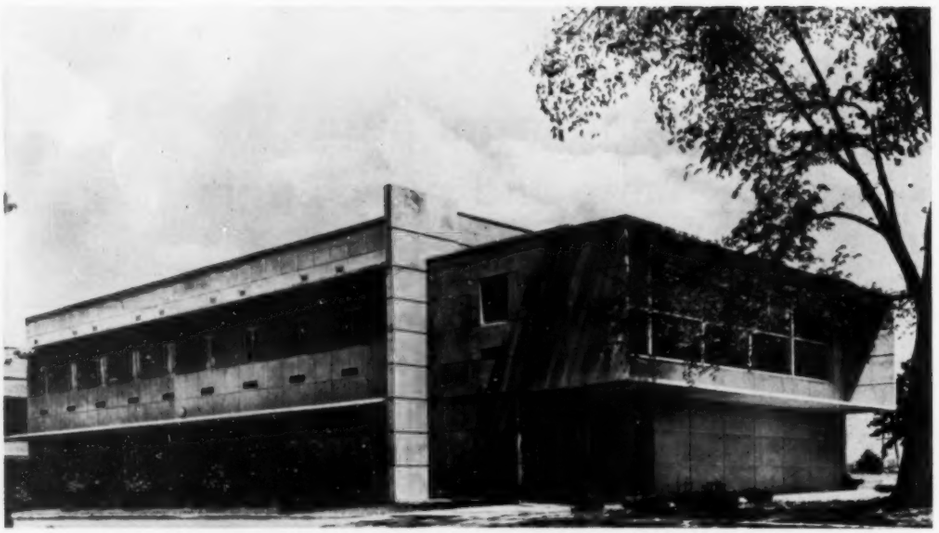

New Petrolite Research Laboratory at Webster Groves, Mo.

New Petrolite Research Center

Petrolite Corp. recently completed a new research laboratory at Webster Groves, Mo., to enlarge product and process studies for its three major divisions, Bareco, Petreco and Tretolite. The new 3-story building encloses 29,000 sq. ft of floor space divided into laboratories, offices, library, and conference rooms.

Developed largely as service and supply units for the petroleum industry, Petrolite activities were built on research. Dr. Frederick G. Cottrell, of the University of California, laid the foundations in 1906 for The Petroleum Rectifying Co. of California. And at almost the same time. William S. Barnickel, a St. Louis chemist, began work which resulted in the establishment of the Tretolite Co.

Both Dr. Cottrell and Mr. Barnickel were challenged by the waste of oil resulting from emulsification. Dr. Cottrell modified an electrical method designed to precipitate solids in flue gases to develop the Petreco dehydrator, while Mr. Barnickel succeeded in breaking down oil-water mixtures by the addition of various chemicals. After a quarter of a century of independent development, the two companies merged in 1931.

Third phase of Petrolite operations is the manufacture of microcrystalline waxes from bottom settlings in crude-oil storage tanks—a natural outgrowth of the treating of "BS&W." This latter enterprise was begun during World War II.

Chemical phase of the Petrolite activity has branched out into the production of scale prevention in oil pipelines and equipment, corrosion prevention, and corrosion inhibitors. More recently, chemicals have been developed to aid fracturing, water flooding, and water disposal through bacteriacides, and wetting agents. The electrical precipitation branch of the company's operations has resulted in the development of desalting of crude and "Electrofining" treating methods for petroleum distillates. Recently, promising work has been done in sulfuric-acid alkylation.

Microcrystalline wax as a product of tank bottoms was a new concept on the part of Petrolite. The company development has been speeded in recent years by research in the application of waxes in the production of "throw-away" carbon paper and "one-time" typewriter ribbon, among many others.

The new research center brings Petrolite investigative work into a modern building equipped to facilitate studies in the specialized fields which the company has entered.

United Adds Catalytic Unit

A UOP fluid catalytic cracking unit, gas concentration unit, and a UOP polymerization plant went onstream recently at the refinery of United Refining Co. at Warren, Pa. The cat cracker has a design capacity of 2,500 b/sd of fresh charge. It is producing a gasoline which has a leader octane number of 98-plus. A 100 F-1 leaded gasoline is being made in the polymerization plant, which is designed to produce 229 b/sd of 10-lb-RVP polymer.

Fino Heads Hammond Engineering

Alex F. Fino, well known in petrochemical and technical circles, has been appointed chief engineer of Hammond Iron Works. He has been with Hammond since 1940, during which period he has had the principal responsibility for the design and development of various Hammond patented products, including the Tubeseal Floating Roof, Dialift, Dialfloat, and other oil-conservation devices.

In addition to committees of the American Petroleum Institute on evaporation loss and tank standardization, he is active with technical groups of the American Welding Socy. and American Socy. of Mechanical Engineers. A technical paper by Mr. Fino on "Field Erection Methods" was recently published in the *Welding Journal*.

Hammond Iron Works has fabricating plants in Bristol and Warren, Pa.; Birmingham, Ala.; Provo, Utah; Casper, Wyo; and field erection crews throughout the world.

Austria Denationalizes Western Oil Property

The Austrian cabinet has denationalized the Shell refinery in Floridsdorf, the Socony Mobil refinery in Kagran, and the Rohoel-Gewinnungs AG. (RAG) (Socony-Shell), as a first step toward the implementation of the Vienna Memorandum. Apparently for tactical reasons, the socialist ministers had opposed this decision until after the recently held presidential elections.

An agreement was also reached over the distribution organization and filling stations of the former Deutsche Gasolin AG, in that from now Gasolin AG's installations in all provinces except Lower Austria and Burgenland are to belong to Shell and Standard Oil Co. of New Jersey (Esso) in equal shares; whereas the Austrian republic is to take over the entire Gasolin AG's property in the two remaining provinces. Shell and Esso each had a 25% share in the Austrian assets of the Gasolin AG; yet, under the Vienna Memorandum, they were to receive also the former German shares in western Austria in exchange for a waiver of their rights to Gasolin AG's property in the eastern parts of the country.

Final parliamentary approval of the denationalization will be given by the steering committee whose sessions are closed. Settlement of the further points of the memorandum will probably be more difficult.

Refiners To Spend $913 Million 3rd Quarter

Petroleum refining companies plan to spend $913 million for new plant and equipment in the third quarter of this year, against $813 million in the same quarter of 1956, according to US Commerce Department. Spending will be by companies in the category petroleum and coal products, but this is chiefly oil refineries.

In all of 1956, spending was $3,135 million. In the first quarter of this year, the spending was $728 million; in the second $976 million. Fourth quarter estimate is not available yet.

Expands Paraxylene Capacity

Standard Oil Co. of California will build a $3 million paraxylene plant at its Richmond refinery to increase output of this chemical by 25 million pounds a year. The new unit, to be constructed adjacent to the present paraxylene production unit at Richmond, will be ready early in 1958. Engineering design is already in progress and site work is expected to begin shortly.

Fighter Joins Cooper-Bessemer

John O. Fighter has joined Cooper-Bessemer Intrenational, as sales engineer. He will direct his efforts to the sales engineering of engines, reciprocating and centrifugal compressors for shipment abroad to pipeline, chemical, and petrochemical industries.

Radiation Research Begun

Sinclair Research Laboratories Inc. is engaged in a long-range research program to find out if nuclear radiation can effect the processing of crude oil or make beneficial changes in petroleum products. Radioactive tracers will be used to determine more about the fundamental properties of petroleum products and what happens to them in use. The radiation and tracer laboratory is the first industrial research facility to use fuel elements from an atomic reactor as its source of radiation. The elements are obtained from the Atomic Energy Commission's materials testing reactor near Idaho Falls, Idaho.

Japanese Ammonia Plant

Chemical Construction Corp., international engineering and construction firm, will design a new ammonia plant for Befu Chemical Co. Ltd in Japan, according to C. A. Harwick, Chemico vice president. Using the Texaco process for the partial oxidation of oil, the plant will have a capacity which can be expanded for the production of 100 tons per day of ammonia.

New Oakite Detergent

Oakite LSD, a new liquid detergent designed for use in solution-lifting steam guns and self-generating steam-cleaning equipment, has just been introduced by Oakite Products Inc., New York. Used as recommended, it is claimed to be safe on steel, brass, and magnesium, and to have no effect on painted surfaces.

Model IV FCC Booklet

Esso Research and Engineering Co., New York, has published a brochure describing the model IV fluid catalytic cracking process. Data are given on mechanical and process features, feed stocks, and process yields. A list is shown of plants now operating or under construction.

Catalyst Plant Operating

Scientific Design Co. Inc., New York, has completed a new plant in northern New Jersey for the production of catalysts for processes developed by SD. Initially, the plant will make silver catalyst for SD's ethylene-oxide process. Eventually, catalysts for other SD processes and custom catalysts will be made.

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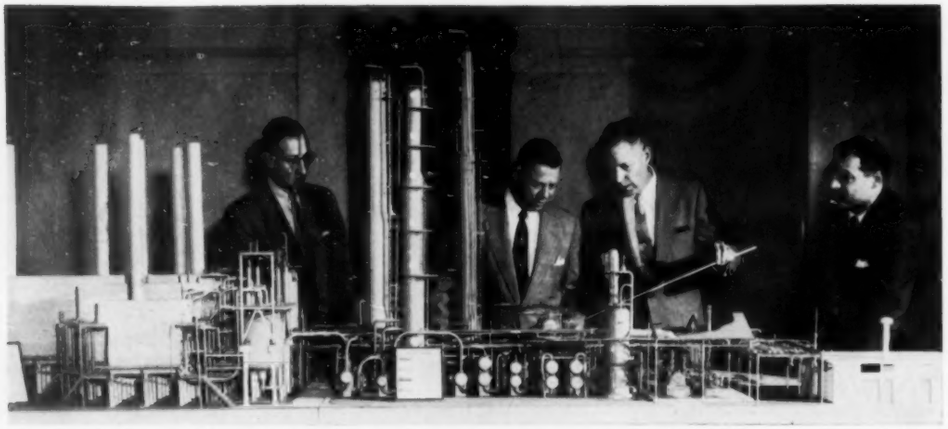

Shown in the photograph is a model of Kellogg's catalytic reforming process unit, built in the company's new model shop. Construction of the actual process unit is now underway at The Pure Oil Co.'s refinery in Lemont, Ill., 25 miles from Chicago. The model, made exclusively of new synthetic materials, is scaled at ¾ in. to 1 ft.

Enjay Announces New Offices

The opening of a new sales office at 16301 West Seven Mile Road, Detroit, Mich., and another at 1410 Canal St., New Orleans, La., has been announced by the Enjay Co. Inc., New York, petrochemical manufacturer. Company's Western Division headquarters also has been changed to Prudential Plaza, 130 East Randolph Drive, Chicago.

Houdry Process Corp. Announces Personnel Changes

Nine personnel changes have been announced by Houdry Process Corp. in its Philadelphia process sales and engineering division and its research division at Linwood, Pa. D. E. Womeldorph and F. R. Walser become commercial development engineers in the sales department, process sales and engineering division. In the sales and engineering division's engineering department, Lee Friedman becomes assistant supervisor-Process Design; R. G. Craig and A. K. Logwinuk, senior process design engineers; and Bent Busch-Peterson, an associate process design engineer. In the same division's technical service department, W. J. Cross has been named assistant supervisor. In the development department, research division, N. M. Kapp has become commerical development section chief; and R. E. Ashwill, chief, chemical engineering section.

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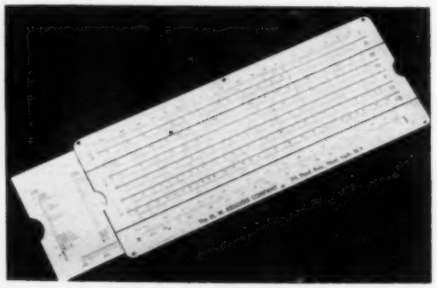
Esso Computing Center

Esso Research and Engineering Co. has announced plans for a large-scale technical computing center at the firm's facilities in Linden, N. J. Heart of the operation will be an IBM 704 scientific computer, on order now for delivery in December. One of the highest capacity technical computers available, with a "memory" for storing some 165,000 digits at one time, the 704 unit will be one of only two in use throughout the entire oil industry. Edwin J. Newchurch has been named an assistant director of the company's petroleum development division, and will be responsible for setting up and managing the center. He had been employed at the Esso Research Laboratories in Baton Rouge, La.

Highest Open-Bid Price

Defense Department, which buys more than a billion dollars a year of petroleum products, has adopted a policy under which it will pay more for what it obtains. In the past, contract awards to small business firms under the set-aside program have been made at the "average" price paid under open-bid parts of procurement invitations. In the future, the small business set-aside is to be paid at the "highest" price paid the open-bid part. Independent refiners have been pressing for this, and they had the aid of the Senate Small Business Committee, where the new ruling was first disclosed. Next step, said the committee, is to try to get civilian agencies to adopt the same policy.



Engineering Slide Rule

A new Equilibrium-Flash Sliderule, developed by the process engineering department of the M. W. Kellogg Co., New York, now enables engineers to make flash, bubble-point, and dew-point calculations in less time than is required for present mathematical procedures. The sliderule is based on a newly developed method which converges toward the final solution more rapidly than the conventional calculation routine. The new sliderule makes it possible to cover in a simple way a wide range of percent vapor and equilibrium constant values without losing accuracy.

Qualified engineers who write on company letterhead to the M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y., will be sent a complimentary sliderule, plus directions for its use.

New UOP Gasoline Sweetener

Universal Oil Products Co. has announced development and commercial availability of a new sweetening inhibitor which employs a selective catalyst to promote more rapid oxidation of sulfur compounds in gasoline. New product is UOP No. 5-S. The formulation, the company said, has been proved in laboratory tests and commercial usage to be even better than previous inhibitors for applications where inhibitor sweetening is the controlling factor in the choice of inhibitor used.

Retaining the potency and water-insolubility characteristics of UOP No. 5 inhibitor, the new additive accomplishes sweetening in one-fourth to three-fourths the time ordinarily required with UOP No. 5, depending upon the mercaptan content and other conditions. The new inhibitor now makes it possible to readily sweeten many gasolines which heretofore had been considered impractical for inhibitor sweetening.

Honeywell Buys Raytheon's Share Of Datamatic Corp.

Minneapolis-Honeywell Regulator Co. has purchased from Raytheon Manufacturing Co. the latter's 40% stock interest in Datamatic Corp. Datamatic was organized jointly by Minneapolis-Honeywell and Raytheon in 1955 to engage in the development of large-capacity high-speed electronic digital data-processing systems for office and business use.

Fluor Completes Synthetic Rubber Unit

First major process unit of Odessa Butadiene Co.'s new 50,000-ton-per-year butadiene plant at Odessa, Texas, has been completed. Construction began last summer by Fluor Corp. Ltd., of Los Angeles, and the plant is scheduled to go onstream in mid-July. Completion of the Odessa plant will mark the first integrated operation since World War II in which synthetic rubber is produced from butane at one location. Located on an 80-acre site in southeast Odessa, the entire $20 million installation was designed, engineered, and is being constructed by Fluor, which has turned over to Odessa the butadiene-recovery section employing the CAA (cuprous ammonium acetate) extraction process licensed by Esso Research & Engineering Co.

Yuba Acquires Lummus Heat-Exchanger Division

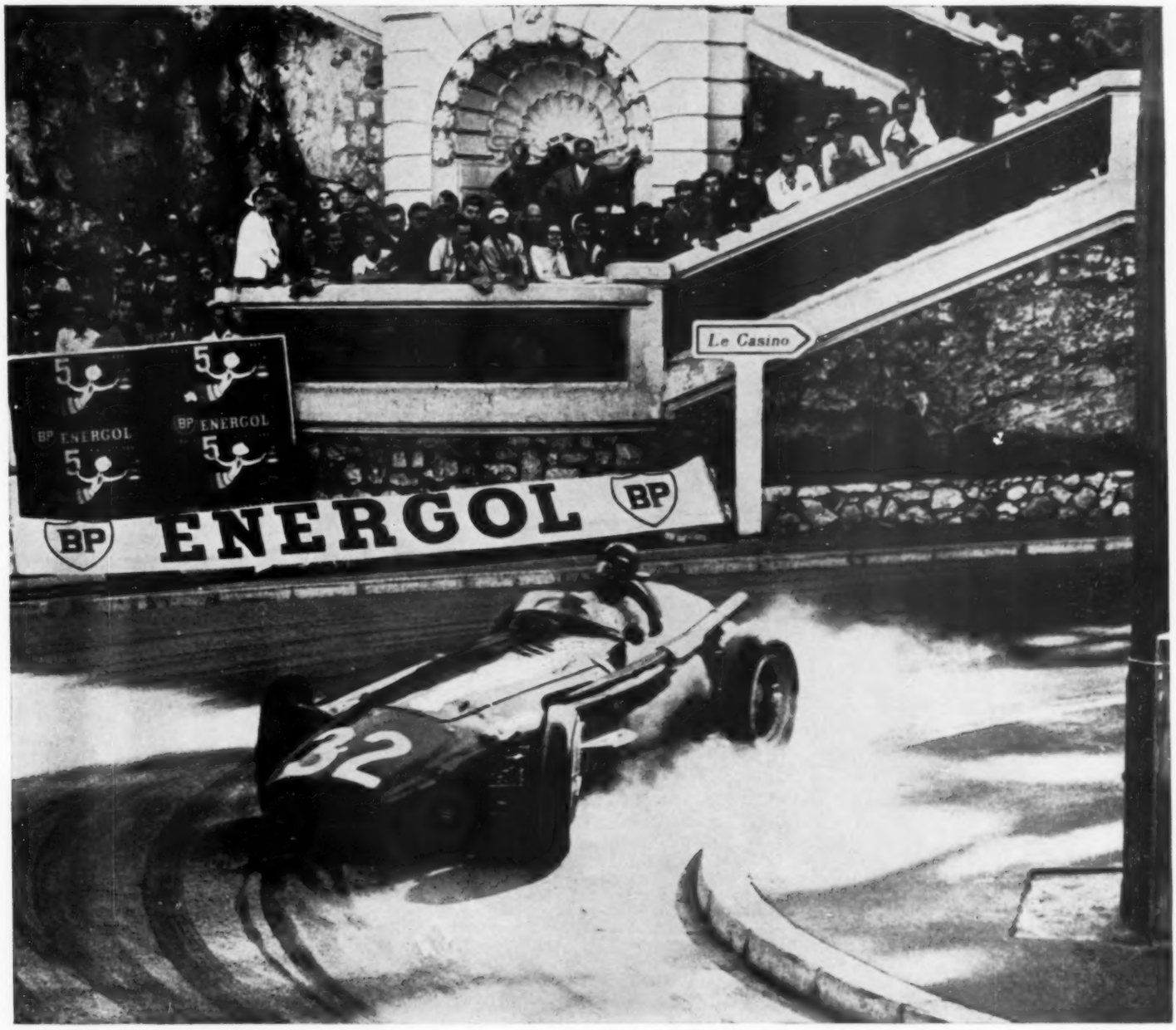
Lummus Co., international engineering and construction firm, has sold Heat Exchanger Manufacturing Division at Honesdale, Pa., to Yuba Consolidated Gold Fields. J. F. Thornton, Lummus' president, has announced this move conforms with company's recent decision to divest itself of its manufacturing divisions in order to concentrate on its main activities—engineering and construction.

George Worn, employed by Lummus for many years in the heat-transfer field, will be actively associated with Yuba.

For Yuba, this represents an expansion in the field of heat-transfer equipment manufacture presently carried on by its subsidiary, Yuba Industries Inc., whose plants have primarily serviced the chemical and petroleum industries until now. Name of parent company will be changed to Yuba Consolidated Industries, Inc.—with headquarters in San Francisco, and plants in Benicia and Richmond, Calif.; Buffalo, N. Y.; and now Honsdale, Pa.

Visigage On Way Out

The sight glass or visigage on the gasoline pump is on the way out, after action by the National Conference on Weights and Measures. The conference, which sets standards adopted by equipment manufacturers and for state laws, voted there is no need for the glass. A committee reported it does not protect the public; may be a fire hazard; makes pumps more expensive; and the glass is hard to keep clean. American Petroleum Institute recommended against it after a one-month survey at 35 stations found little consumer interest.



Juan Fangio, driving a Maserati, rounding Tobacco Corner at speed during the Monaco Grand Prix, which he won using BP Fuels and BP Energol Motor Oil

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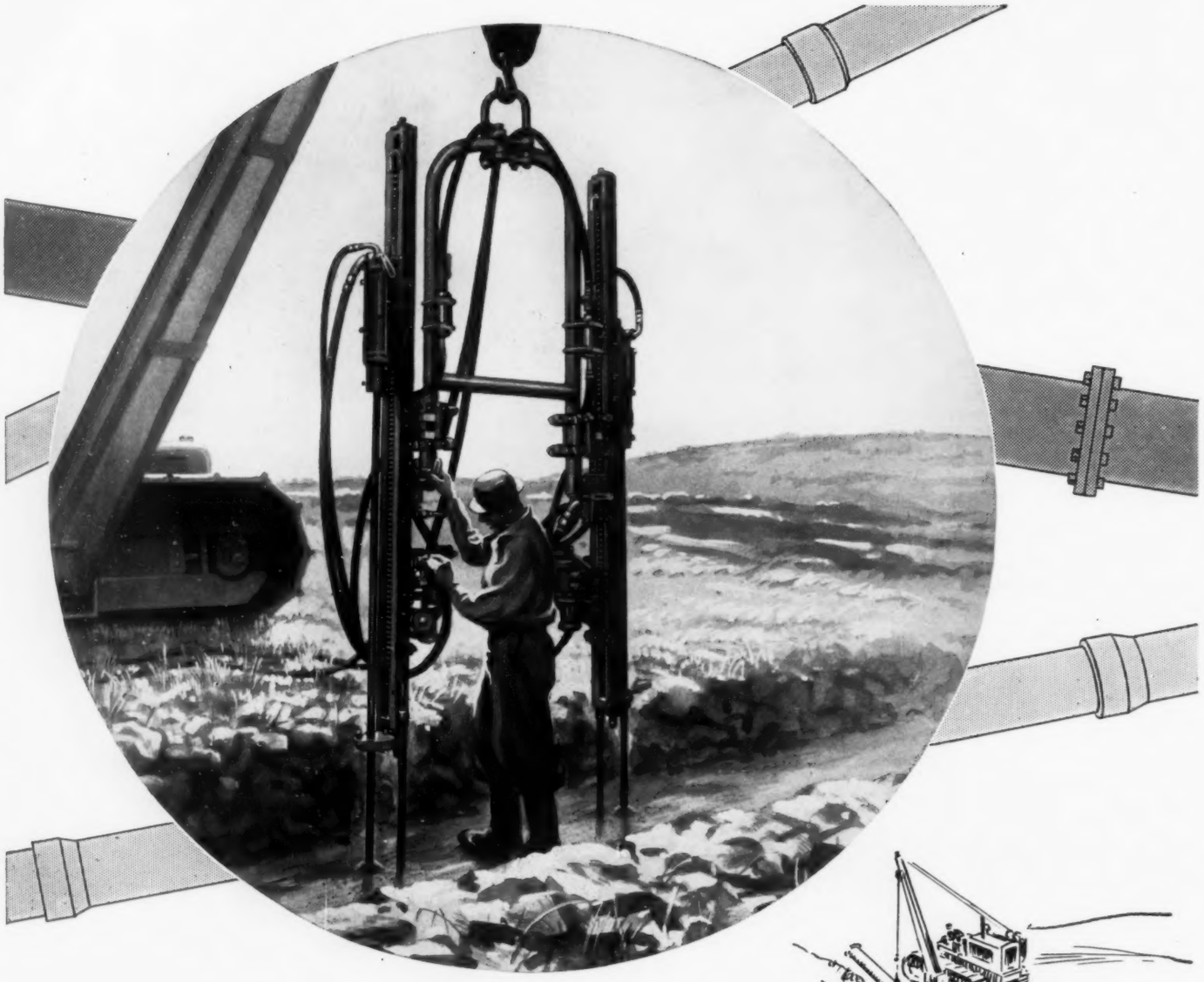

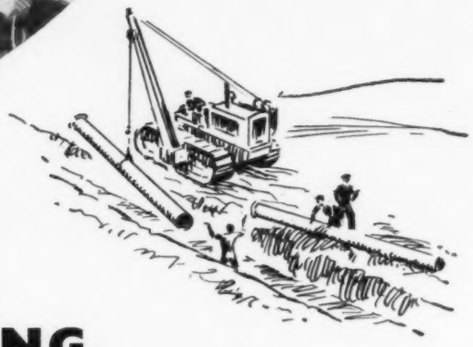

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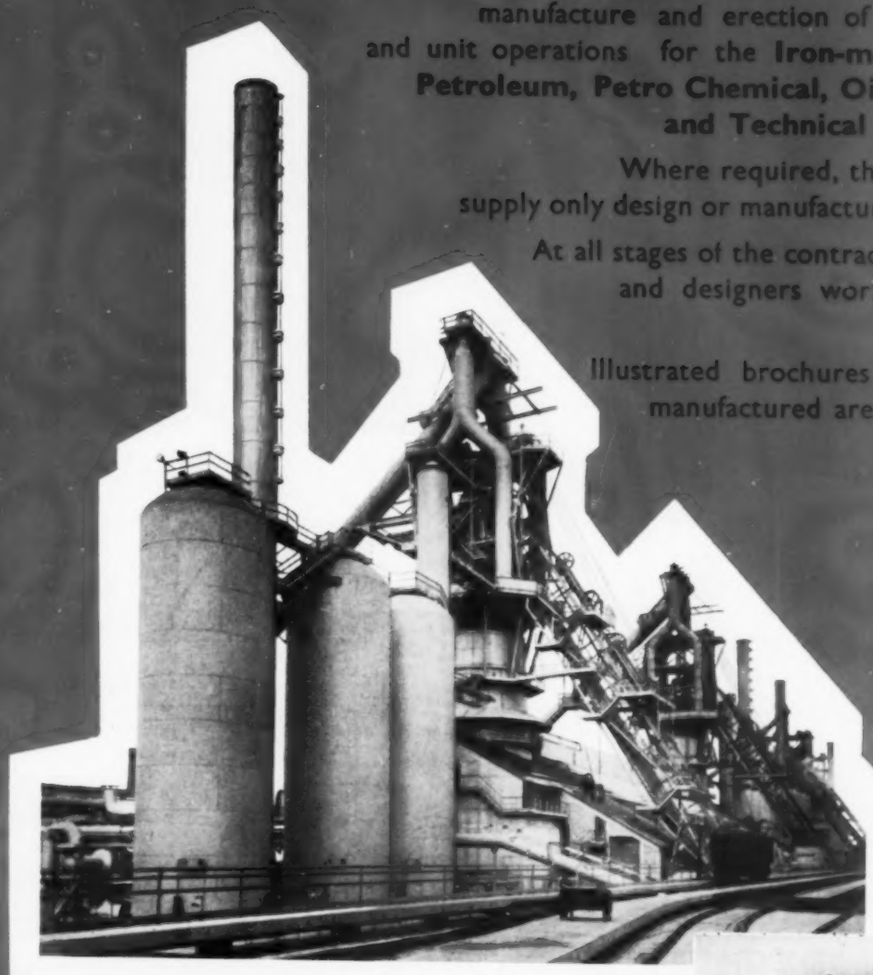

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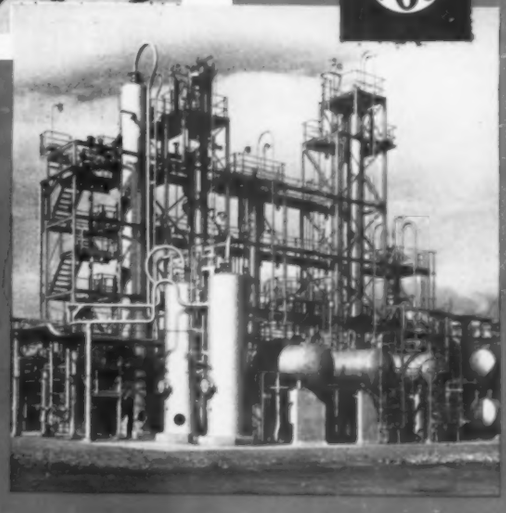

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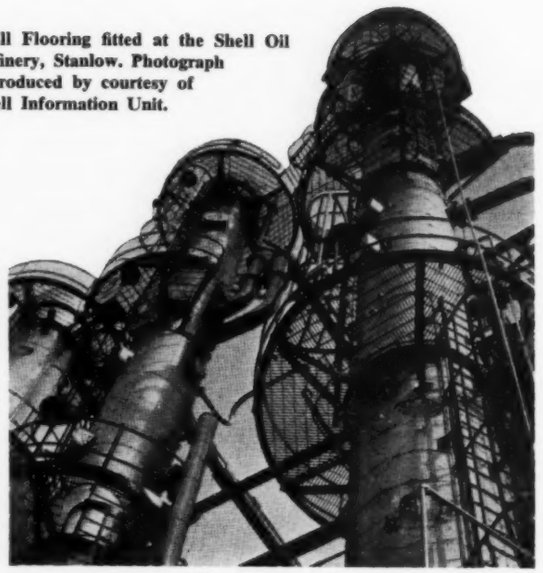
Grill Flooring fitted at the Shell Oil Refinery, Stanlow. Photograph reproduced by courtesy of Shell Information Unit.



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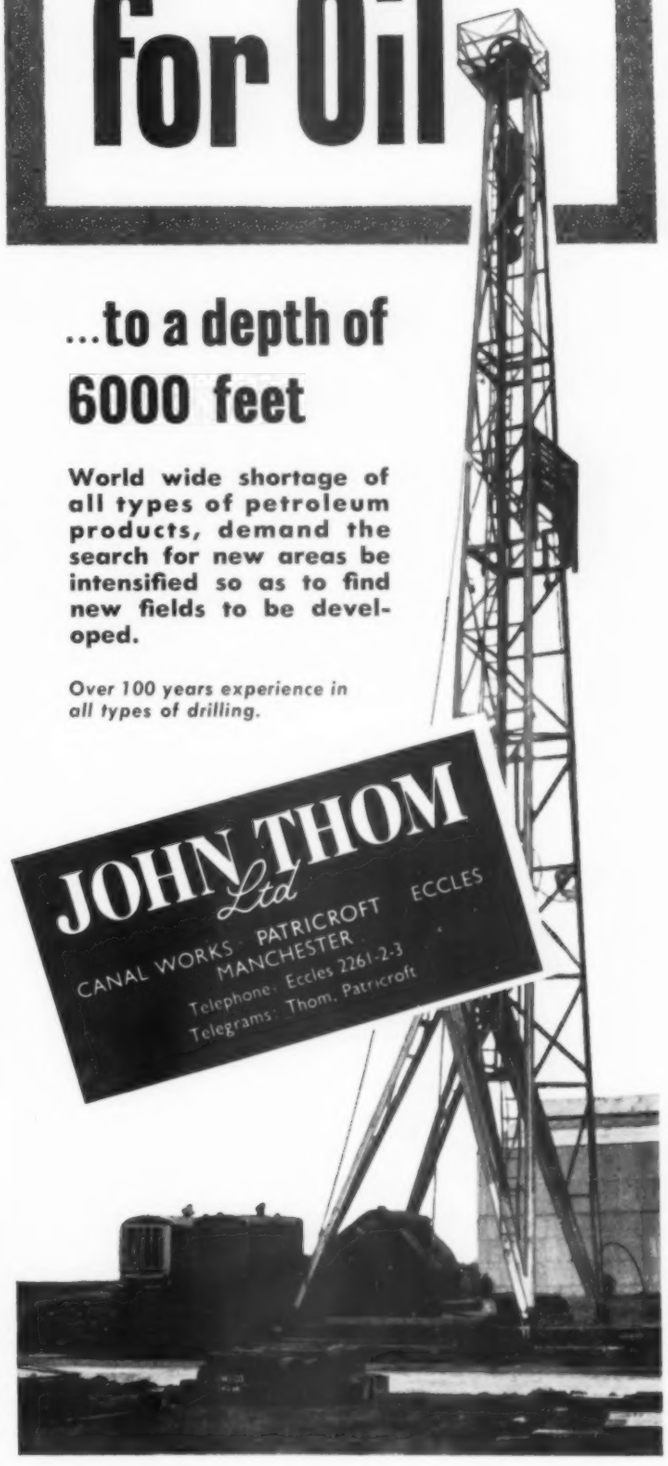

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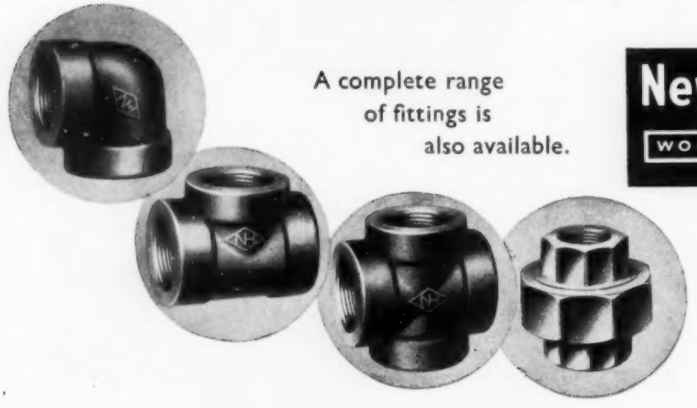

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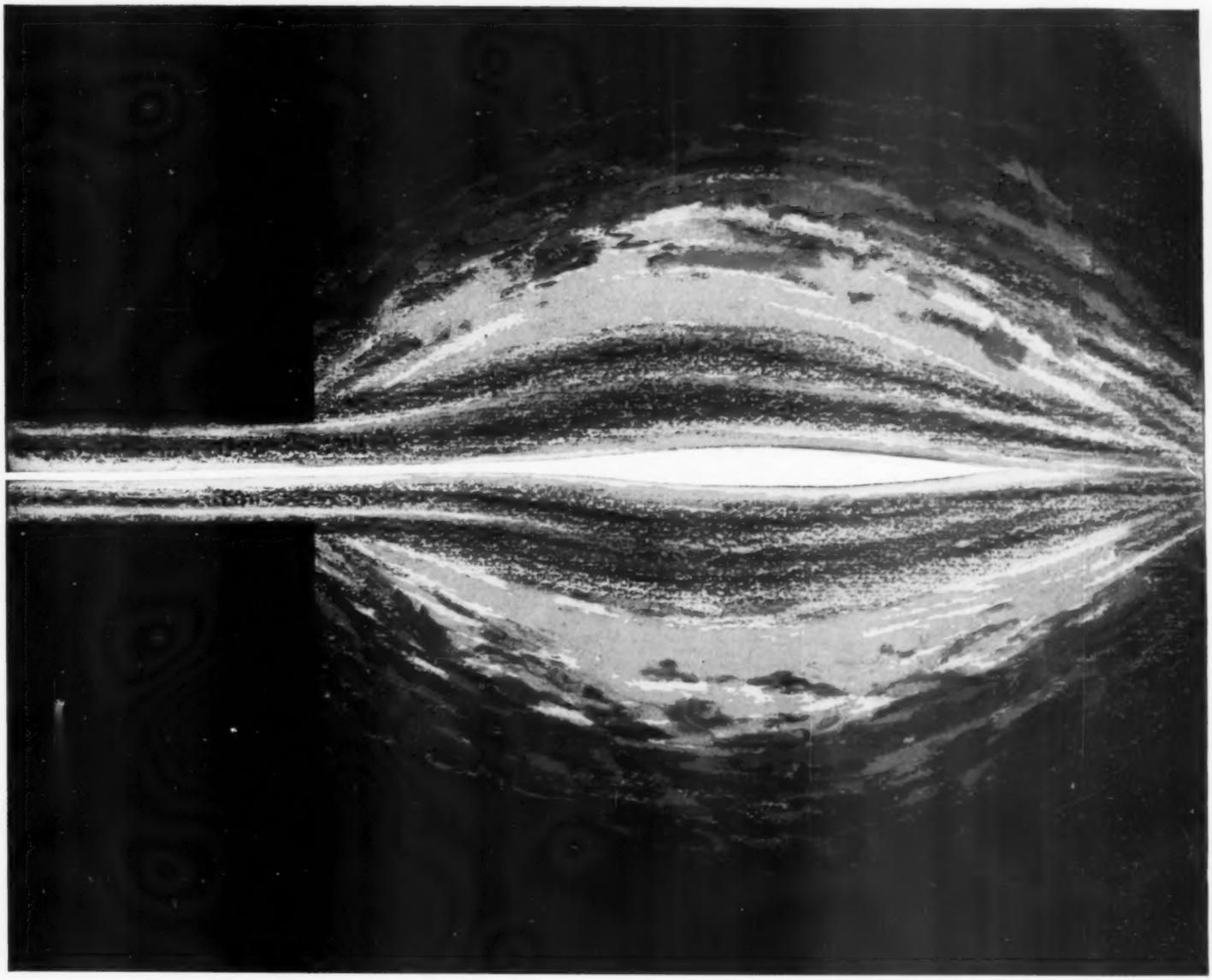

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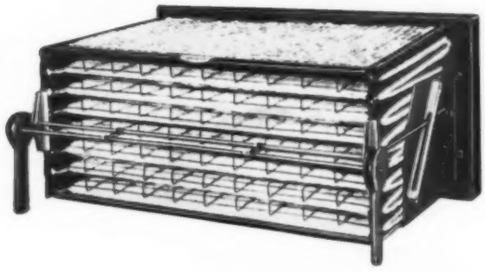

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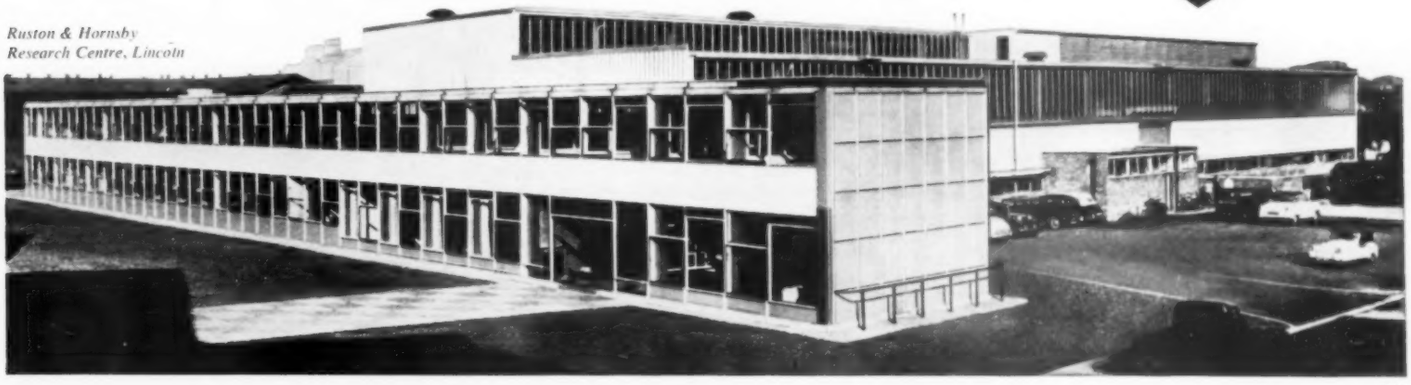

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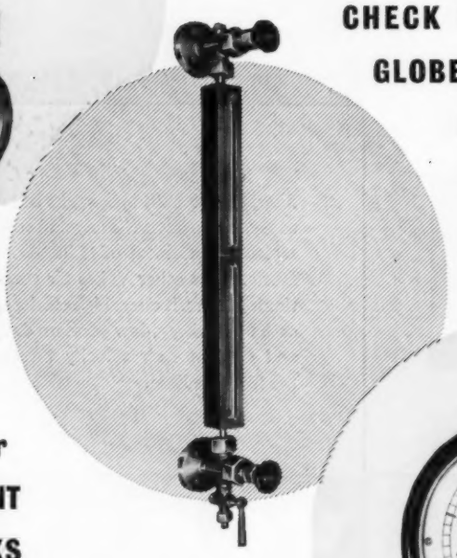

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